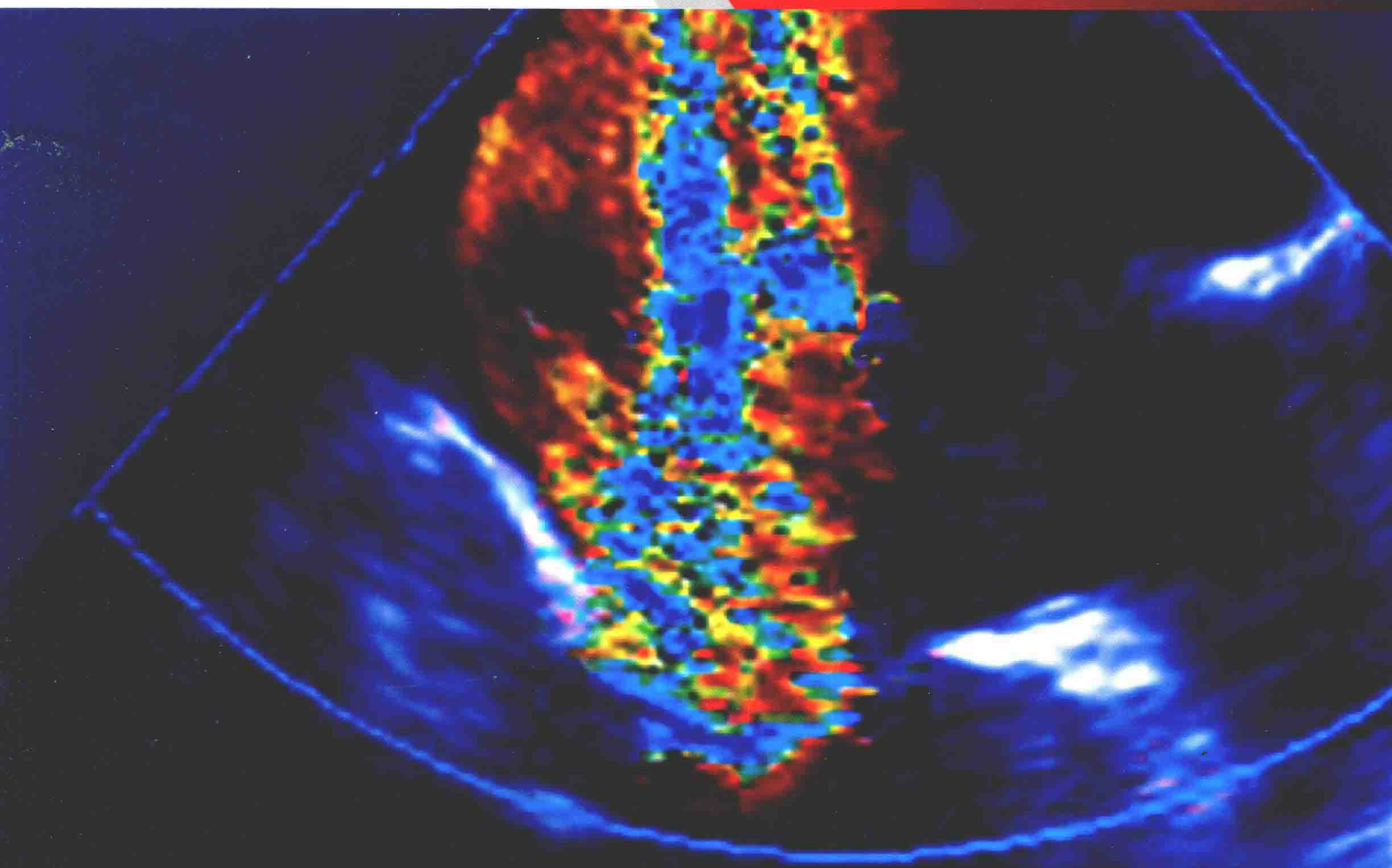

CRITICAL CARE ULTRASOUND

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To Christine

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To Lily

*

The Critical Care Ultrasound *textbook is dedicated to critical care patients and to their families.*

FOREWORD

Ultrasound is energy generated by sound waves of 20,000 or more vibrations per second. The history of ultrasonography can be premiered by Leonardo da Vinci (1452-1519), who recorded experiments in sound transmission through water. Lazaro Spallanzani (1729-1799), an Italian priest and biologist, studied the movements of bats and concluded that bats use sound to navigate.

The first reported ultrasonic source was the Galton whistle, developed by the English scientist Francis Galton (1822-1911) from his studies on the hearing frequencies of animals. In 1880, brothers Jacques and Pierre Curie discovered piezoelectricity, or electrical charges produced by quartz crystals subjected to mechanical vibration. Piezoelectricity is fundamental to creating sound waves in modern ultrasonic transducers. Later in 1903, Pierre Curie, with his wife, Marie Curie, received the Nobel Prize in Physics for their work on radioactivity.

The use of ultrasound in medicine started in the 1940s. Karl Theodore Dussik of Austria published the first paper on medical ultrasonography in 1942, based on using ultrasound to investigate brain tumors. In 1949, George Ludwick in the United States published his work on ultrasound to detect gallstones.

The 1950s and 1960s saw pioneers in the United States, Europe, and Japan work on medical applications of ultrasonography. Deserving of mention were Kenji Tanaka (Japan), Inge Edler (Sweden), and Ian Donald (Scotland). John Wild and John Reid (United States) are credited with developing the first hand-held ultrasound device, and Douglas Howry (United States) largely pioneered 2-D ultrasound imaging.

Advances in the past 20 years have seen new developments like real-time imaging, color Doppler, 3-D imaging, and now 4-D imaging. Medical applications of ultrasonography, initially used in obstetrics and cardiology, are now seen in surgery, anesthesia, critical care, emergency medicine, internal medicine, and pediatrics. Increasingly, critical care physicians rely on bedside ultrasonic examinations on their patients to diagnose, monitor, and guide interventional procedures (such as placement of needles or cannulas). By the nature of critical illness, the ICU patient's condition may change while in the unit or while in the ED or ward, to require an urgent bedside examination. An ultrasound examination may significantly help clinical management. The critical care physician would not be complete today without knowledge and relevant skills in ultrasonography.

Critical Care Ultrasound presents the application of ultrasound in critical care. It describes the indications, processes, and protocols to perform ultrasound procedures in the ICU. The field of topics presented is wide, covering neurological, pulmonary, cardiovascular, and abdominal applications, and in special settings. There are more than 80 contributors of experts and acclaimed authors. This book is a tremendous resource of practical knowledge and reference material. It will be of great help to trainees, critical care specialists, ICU nursing, allied health professionals, and anyone practicing acute medicine. Editors Philip Lumb and Dimitrios Karakitsos and the contributors are to be congratulated.

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As a medical student in the mid-1970s, I was taught that if a diagnosis was uncertain after obtaining a history, the likelihood of obtaining an accurate understanding of the patient's condition was reduced significantly because the subsequent physical examination was likely to be unfocused. Nonetheless, the instruction was to perform the follow-up examination in the remainder of the HIPPA acronym: History, Inspection, Palpation, Percussion, and Auscultation. If, following the complete physical examination that incorporated all aspects of the "IPPA" requirements, a diagnosis remained elusive, the likelihood that the then available special investigations would provide definitive help was low. The advent of CT, MRI, and PET imaging, point-of-care testing, and a variety of additional computer-assisted techniques have made the preceding sentence irrelevant. However, today's critical care physician is challenged with an immediate need to understand and treat physiologic abnormalities that may not be amenable to patient transport to an imaging facility, or elucidated by another stat chemistry or blood gas result.

The desire to penetrate the skin's surface "visually" has been a long-standing physician's wish; however, it is not a static image but rather a dynamic portrayal of physiologic function that has eluded bedside analysis and capability. Today, portable ultrasound units afford this capability and provide physicians the ability to interrogate and "see" target organs and evaluate current function and potential reserve in real time. The most highly developed analyses involve cardiac function, but newer capabilities exist to evaluate cerebral blood flow, lung function, renal perfusion, intracranial pressure abnormalities, peripheral vascular integrity, and additional examinations detailed in this textbook. The realization that physicians can "see" and assess physiologic function in real time is a tipping point in critical care; the reality is if intensivists are not embracing the technology today, their professional development will be limited and their ability to care for their patients compromised.

The authors of *Critical Care Ultrasound* are recognized experts in the field and highly regarded practitioners. Their insights provide valuable instruction in adapting ultrasound examinations into routine clinical practice, and their experience lends credibility to the remarks and *Clinical Pearls* that accompany each chapter. The definition of a textbook's success is its ability to titillate interest and stimulate changes in practice behaviors; it is our hope that we succeed in this endeavor and that an ultrasound examination becomes a routine procedure, not only in cases of acute patient deterioration, but also in daily bedside rounds. The capability to predict adverse events cannot be underestimated; we would be intellectually remiss not to embrace the opportunity to improve our diagnostic and interventional capabilities.

Philip Lumb

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We, Philip Lumb and Dimitrios Karakitsos, would like to thank our teams and associates for supporting this edition. We wish to express our gratitude to the numerous distinguished colleagues from Australasia, the Middle East, Europe, and North America who participated in this textbook by providing pearls of their own. We wish to express our appreciation to all medical students, residents, and nurses who provided inspirational criticism regarding the application of ultrasound technology in the intensive care unit.

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Introduction

The proven benefits of on-demand bedside ultrasound imaging in the management of the critically ill patient go far beyond the initial diagnostic assessment, ranging broadly from facilitating safer and quicker procedures, to monitoring disease trends and effects of instituted therapy. Notwithstanding the rapidly growing evidence base, critical care ultrasound is still lacking conceptual definition and a clear implementation strategy in order to become a universally accepted tool for routine management of critical care patients. The setting of an intensive care unit is vastly different from pre-hospital care or emergency department, and the bedside imaging paradigms in these two settings are different as well. One of the most critical differences is that although the same patient who was cared for by pre-hospital personnel and then treated in the emergency department is now in the intensive care unit, he or she are on different points in the continuum of his or her critical illness. This means different challenges and findings are encountered, and different treatments and ultrasound approaches may be required. It is not the increasing portability of modern digital scanners or their declining cost that that will bring appropriate imaging capability to more intensive care units; it is the shared understanding among intensivists, health care managers, educators, and other stakeholders of its benefits for the patient as well as for their respective areas of activity. Such understanding is essential to minimize the time lag we are in currently between technology readiness and its full implementation into practice.

As with any technology, critical care ultrasound is only as good as the knowledge and skills of its users. The editors and authors of this volume have made a bona fide effort to create a resource for intensivists that contains a massive amount of learning and reference material presented clearly, concisely, and with clinical relevance in mind.

The *Holistic Approach (HOLA)* concept of ultrasound imaging introduced in the book defines critical care ultrasound as part of the patient examination by a clinician to visualize all or any parts of the body, tissues, organs, and systems in their live, anatomically and functionally interconnected state and in the context of the whole patient's clinical circumstances. Throughout the volume, this universality of ultrasound imaging is accentuated; generic imaging, specific imaging protocols, and image-based procedure techniques are explained in the context of critical care patient management. The authors provide a thorough, mature substantiation for the HOLA concept and its elements, which are further used to present and defend a rational implementation strategy for ultrasound in intensive care units, including another novel concept—the critical care ultrasound laboratory—an advanced facility that carries out specialized imaging techniques and image-based procedures, ensures centralized data management, and serves as an interface with radiology and other services external to the critical care facility. All these efforts have one central purpose: to help the readers integrate ultrasound into their clinical practice at the highest level possible and as broadly as desired.

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