Arts and Medicine

The art and science of ultrasound imaging: medical applications of ultrasound in diagnosis and therapy and its impact on patient care

Julia H. Miao

Renaissance School of Medicine at Stony Brook University, New York, NY, USA

Correspondence to: Julia H. Miao. Renaissance School of Medicine at Stony Brook University, New York, NY, USA. Email: jhm344@cornell.edu.

Submitted Oct 24, 2022. Accepted for publication Dec 07, 2022. Published online Jan 10, 2023.

doi: 10.21037/cdt-22-537

View this article at: https://dx.doi.org/10.21037/cdt-22-537

Introduction

Making waves at the frontiers of medicine, the rise of clinical ultrasound in today's 21st century highlights its many robust applications in medicine and guiding patient-centered management for patients at the bedside. Illuminated through photography and long exposure light technique, "Riding the waves" captures the serenity of the sea at sunrise (*Figure 1*); the waves and long exposure of colorful light rays within the photograph reflect the waves and echoes of that of ultrasound and its diverse applications in various subspecialties within medicine. Like the gentle waves of a calm ocean, ultrasound is a safe, non-invasive, and efficient imaging tool utilized to assess and diagnose patients and guide appropriate medical intervention that can improve the lives of patients globally.

History of medical ultrasound in diagnosis and therapy

Ultrasound finds its beginning origins from its applications under water, measuring distance with the speed of sound in water and exploring vibrations, transmission, and propagation. During the 1940s, medical applications of ultrasound emerged. Dr. Karl Theodore Dussik in Austria applied ultrasound transmission to study the brain and was the first to publish work on its use in medicine (1). Heading into the 1950s, physicians first sought to use the innovation of ultrasound for therapy, rather than diagnostics. Doctors applied relatively low frequencies and amplitude to the surface of the body as a way of pressure therapy and "internal massage". Early clinical applications also included physical therapy and rehabilitation for rheumatoid arthritis patients and even emerging investigations of focused ultrasound for potential ablation of tumors.

Since then, rapid advances in science and technology facilitated the improvement of medical ultrasound in diagnostics, from still images to real-time moving images. Eventually, faster processing speed and power with the microchip and other technologies enhanced new visualization into color Doppler that showed real-time circulation within the human body and even 3D imaging. By relying on sound waves rather than ionizing radiation, ultrasound gave clear pictures of soft tissues and underlying anatomy (2). This unparalleled advancement in science and technology offered ultrasound multiple advantages, including its safety, non-invasive applications, efficacy, and cost efficiency.

Applications of ultrasound in medicine and patient care

Due to its diverse applications, ultrasound is utilized by physicians in various subspecialities of medicine. In emergencies, clinicians apply point-of-care ultrasound in high-acuity and trauma cases to assess areas of bleeding within the body and to rapidly apply surgical intervention to save patients' lives. In operating rooms, anesthesiologists and cardiologists also utilize transesophageal echocardiogram to examine the structure and function of the heart. In pediatrics, obstetrics, and gynecology, ultrasound is the preferred imaging modality for providing safe diagnosis and monitoring for pregnant mothers, fetal health, newborns, and children (3).

Figure 1 Riding the waves.

In addition to diagnosis, ultrasound can help guide biopsy and therapeutic intervention. Radiologists use ultrasound-guided biopsy to assess tumors and pathological findings in the liver or breast, for example. In pain medicine, physicians also apply ultrasound to guide analgesics in musculoskeletal structures to help relieve the pain and suffering for acute and chronic pain patients. Furthermore, emerging areas of research have highlighted potential unrealized applications of High Intensity Focused Ultrasound for advanced drug delivery and therapy, including hyperthermia-induced drug delivery and thrombolysis (4).

Last but not least, like the boundless oceans across the globe, ultrasound shines due to its wide availability and invaluable applications in global health. Especially for patients in developing countries and underserved areas with scarce healthcare resources, ultrasound offers a cost-effective option that enhances accessibility. Whereas expensive medical imaging such as computed tomography (CT) and magnetic resonance imaging (MRI) are often not available in these underserved areas, ultrasound aids in bridging the gap of healthcare disparities and thus enhances medical equity.

Conclusions

The dynamic history of ultrasound in medicine from diagnostics to therapy illuminates its robust clinical applications to aid patients globally. Like the sunrise within the photograph captured in "Riding the waves", the incredible advancement of ultrasound in medicine inspires hope, paving new bright directions of diagnosis and medical therapy and ultimately improving the lives of our communities globally.

Author's statement

Julia H. Miao graduated from Cornell University and is a medical student at the Renaissance School of Medicine at Stony Brook University. Dedicated to caring for her patient communities, Julia enjoys engaging in her passions for humanistic medicine and medical education through patient advocacy, research, and visual art narratives.

Acknowledgments

Funding: None.

Footnote

Conflicts of Interest: The author has completed the ICMJE uniform disclosure form (available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-537/coif). The author has no conflicts of interest to declare.

Ethical Statement: The author is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Cite this article as: Miao JH. The art and science of ultrasound imaging: medical applications of ultrasound in diagnosis and therapy and its impact on patient care. Cardiovasc Diagn Ther 2023;13(1):109-111. doi: 10.21037/cdt-22-537

References

1. Duck F. Ultrasound – The First Fifty Years. Medical Physics International 2021;5:470-98.
2. Miao JH, Miao KH. Springing into life: the harmony of human anatomy, nature, and patient care. Cardiovasc Diagn Ther 2021;11:339-40.
3. Miao JH, Miao KH. Cardiotocographic Diagnosis of Fetal Health based on Multiclass Morphologic Pattern Predictions using Deep Learning Classification. International Journal of Advanced Computer Science and Applications (IJACSA) 2018;9:1-11.
4. Phenix CP, Togtema M, Pichardo S, et al. High intensity focused ultrasound technology, its scope and applications in therapy and drug delivery. J Pharm Pharm Sci 2014;17:136-53.

