

Special Issue for Biomedical Ultrasound: Towards Further Advances in Fundamentals and Applications by Comprehensive Reviews

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Abstract

In this paper, the rationale and contents of the special issue of the Journal of the Acoustical Society of Korea regarding comprehensive reviews on past, present and future of biomedical ultrasound are described. Brief descriptions of invited articles are given, and efforts by all contributing authors are gratefully acknowledged.

Keywords: *Biomedical Ultrasound, B-mode imaging, Vector Doppler Imaging, High Frequency Ultrasound, High Intensity Focused Ultrasound, Extracorporeal Shock Wave Therapy, Ultrasound Transducers, Volumetric Imaging, Ultrasound Elasticity Imaging, Acoustics Properties, Diagnosis of Osteoporosis, Ultrasonic Backscattering, Safety Parameters of Medical Ultrasound, Thermal Index, Mechanical Index, Cellular-Level Biomechanics of Ultrasound*

I. Introduction

It is well known that the academic endeavors in science spawn technological innovations. Besides catering to their academic interests, scientists and engineers play a key role in shaping national agendas for the industrial and economical growth and national welfare. Recently, a new trend so-called fusion technology has garnered attention as emerging technology for future promising business. Biomedical ultrasound is, at present, a multidisciplinary technology among acoustics, electronics, mechanics, and medicine, and has potentials to be one of them. Considering the explosive growth of aging populations around the world, the role and economic impact of biomedical ultrasound in healthcare will become even more significant.

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Since the commercial introduction of diagnostic imaging system for human body in the late of 1940s and early 1950s, there have been many technological advances in diagnostic ultrasound. In addition, the observation of dead fish near a high-power echo-ranging system by C. Chilowsky and P. Langevin in 1972 first brought attention to ultrasound-induced bioeffects. [1] It motivated the expansion of the ultrasound use from diagnosis to therapy, surgery, and cancer treatment. Therefore it is fitting to review the current status and the future of the equipment-based biomedical ultrasound technologies covering not only diagnostic ultrasound but also therapeutic and surgical application.

Because of the potential harmful bioeffects of ultrasound, studies concerning the ultrasound safety were performed for regulatory requirements. In a constant push for global harmonization, the international regulatory standards will increasingly be used to

approval of newly-developed clinical ultrasonic equipments. This underscores the importance of regulatory standards because they can serve as an effective means to present a technical barrier to entry in an increasingly competitive global market. Thus, reviews of ultrasound-induced bioeffects regarding the human exposure and regulatory matters are also addressed in the special issue.

In this paper, the author gives a brief description of each invited article in this special issue of the Journal of the Acoustical Society of Korea.

II. Summary of the invited articles

This special issue contains three categories as 1) Review of equipment-based biomedical ultrasound technology, 2) Acoustic properties of tissue and mimicking materials, 3) Bioeffects of ultrasound.

Review of equipment-based technology covers the papers written by three qualified authors. The technology of B-mode imaging opened the market and made a decisive contribution enlarging its market volume consistently till now. M. H. Bae [2] describes the evolution of signal process technology in his article entitled "Evolution of Signal Processing Technology for Medical Ultrasound B-mode Imaging."

In addition to anatomical information gleaned from B-mode images, Doppler image offer such new possibilities as the assessment of cardiovascular function and contribute to make ultrasound technology popular in clinical market. S. J. Kwon [3] describes the various two-dimensional velocity estimation methods in their article entitled "Velocity vector Doppler imaging." The technology addressed in his article is expected to overcome the limitation of angular dependence of blood flow velocity of the conventional Doppler image.

Frequencies higher than 20 MHz are essential to achieve higher resolution. The emerging technology of HFUS (high frequency ultra-sound) expected to enable the ophthalmic, dermatologic, and vascular use with the less penetration and high resolution. T.

H. Bok and D. G. Paeng [4] address this topic with relevant transducer technology in their article entitled "High frequency ultrasound and its applications to animal and human imaging focusing on vessel and blood."

Because ultrasound involves no ionizing radiation, and is non-invasive and relatively easy to control, it is believed to be safer than other radiations in medicine. The high energy of ultrasound, however, can sufficiently heat and eventually necrotize cells and tissues in the body through thermal and mechanical effects. The power-controlling, focusing, and collimating technology of ultrasound opened the doors to the advent of the HIFU (high intensity focused ultrasound) technology. J. Seo [5] describes the HIFU technology with monitoring means in his article entitled "High intensity focused ultrasound for cancer treatment: Current agenda and the latest technology trends".

The high-amplitude acoustic pressure pulse having very short duration achievable by focusing can cause a significant mechanical effect at a boundary between soft (low specific acoustic impedance) and hard (high specific acoustic impedance) media, and can be used to break stones in the body. This effect is harnessed in lithotripsy and orthopedic treatment. M. J. Choi and S.C. Cho [6] discuss the physical aspects of the shock waves used in lithotripsy as well as critical issues regarding exposure optimization in their article entitled "Extracorporeal shock wave therapy: its acoustical aspect."

There has been an essential support of the key components (ultrasonic transducer) converting the energies from electrical to acoustical and vice versa, in current technical advances of all the ultrasound medical equipments. The leading-edge of ultrasound transducer technology is perhaps transducers used volumetric (three-dimensional) image. Y. Rho [7] describes two representative types of 3-D imaging transducers in his article entitled "Ultrasound transducers for medical volumetric Imaging."

Acoustic properties of material such as sound velocity (group velocity and phase velocity), specific acoustic impedance, elastic modulus, dispersion, and

acoustic attenuation coefficient are important in designing medical ultrasound equipments including phantoms used for the assessment of image quality. M. K. Jeong and S. J. Kwon [8] review various elasticity imaging methods and operational principals in their article entitled “Ultrasound elasticity imaging methods.”

The quantitative ultrasound based on sound speed and attenuation coefficient has a lot of possibilities in application to diagnostic ultrasound. For instance, ultrasonic, diagnosis of osteoporosis is steadily encroaching into the popularity of more traditional techniques such as DEXA (Dual Energy X-ray Absorptiometry). K. I. Lee and S. W. Yoon [9] describe quantitative ultrasound diagnosis of osteoporosis with several theoretical models for ultrasonic wave propagation in bones in their article entitled “Ultrasonic diagnosis of osteoporosis.”

Various tissue-mimicking phantoms are used to the quality assurance of diagnostic ultrasound equipments. Those phantoms are usually made by mixing the scattering particles in a tissue mimicking material. H. C. Kim and Y. T. Kim [10] describe micro-structural parameters associated with physical, geometrical, acoustical, and mechanical origins of frequency variation in their article entitled “Influence of microstructure on reference target on ultrasonic backscattering.”

By the reason that recent regulatory international standards stipulate the safe use of medical ultrasound, the safety parameters of medical ultrasound such as thermal index and mechanical index (TI and MI) are developed and modified as necessary in the technical committee 87 (Ultrasonics) and 62 (Medical Electrical Equipment) of International Electro-technical Commissions. In this light, the article entitled “Introduction of the international regulatory standards regarding the all known mechanisms, such as thermal and mechanical effect as well as their safety parameters such as thermal index and mechanical index,” was supposed to appear in this special issue. Unfortunately, the article could not be published on time, for which this author owes an apology.

In addition to the existing safety parameters (TI

and MI), there are some recent attempts to introduce safety/efficacy parameters, addressing different aspects of ultrasound-induced bioeffects. W.-S. Ohm [11] summarizes recent endeavors in this area with specific focus on the ultrasound-cell interaction in his article entitled “Cellular-level biomechanics of ultrasound.”

Finally, a review of metrology related medical ultrasound was considered at first time. This topic, however, was dropped, because the harmonization with other topics seemed rather difficult.

III. Concluding remark: Acknowledgements

In this paper, the motivation for organizing a special issue on the status quo ante and the future of biomedical ultrasound was described.

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【Profile】

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