

Physical Bases of Elastography. Part 2. Shear Wave Elastography (Lecture)

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Abstract

The lecture outlines the physical principles of a shear wave elastography, a new method of echography, based on the use of shear waves with the oscillations of the particles in the plane transverse to the direction of propagation of the wave. Shear waves can be excited by radiation pressure of an ultrasonic wave focused in given points at required depth, from which they will propagate in the transverse to the beam axis direction at a speed determined by the shear elasticity of tissues. After measurement the speed in the whole range of depths under study, it is possible to compare the quantitative indicators of the shear elasticity of tissues and create their two-dimensional grey-scale or color image. The method does not require the compression of tissues by sensor that provides good reproducibility of results, objectivity and better visualization.

Key words: Ultrasound Diagnostics, Shear Wave Elastography, Transverse Shear Wave, Radiation Pressure of Ultrasound, Elastometry, Shear Module of Elasticity.

References

1. *Andreev V. G., Dmitriev V. N., Pishchal'nikov Yu. A., Rudenko O. V., Sapozhnikov O. A., Sarvazyan A. P.* Observation of Shear Waves Excited by Focused Ultrasound in the Rubber-like Medium. *Acoustical Physics*. 1997. V. 43. No. 2. P. 123–128 (in Russian).
2. *Zykin B. I., Postnova N. A., Medvedev M. E.* Elastography: Anatomy of a method. *Radiation Diagnostics, Radiation Therapy*. 2012. No. 2–3. P. 107–113 (in Russian).
3. *Rudenko O. V., Soluyan S. I.* Theoretical foundations of nonlinear acoustics. New York: Plenum, Consultants Bureau, 1977 (in Russian).
4. *Rudenko O. V., Sarvazyan A. P.* Wave Biomechanics of the Skeletal Muscle. *Acoustical Physics*. 2006. V. 52. No. 6. P. 720–732 (in Russian).
5. *Strelkov S. P.* Mechanics: Textbook. 4th ed., Stereotype. SPb.: Lan', 2005. P. 560 (in Russian).
6. *Andreev V. G., Shanin A. V., Atletova E. A., Demin I. Yu., Rudenko O. V., Krainov A. I.* Acoustic Radiation Force on a Cluster of Rigid Particles in Soft Tissues. Proc. 5th Int. Conference «Frontiers of Nonlinear Physics». N. Novgorod, Russia, IAP RAS, 2013. P. 51, 52.
7. *Demin I. Yu., Rudenko O. V., Gurbatov S. N., Pronchatov-Rubtsov N. V.* The Nonlinear Decay of Narrowband and Broadband Noise in Soft Tissues. Proc. 5th Int. Conf. «Frontiers of Nonlinear Physics». N. Novgorod, IAP RAS, 2013. P. 24–30.
8. *Garra B. S.* Tissue elasticity imaging using ultrasound // *Applied Radiol.* 2011. No. 2. P. 24–30.

9. *Sarvazyan A. P., Rudenko O. V.* Method and apparatus for elasticity imaging using remotely induced shear wave. 1998. US Patent 5810731.
 10. *Sarvazyan A. P., Rudenko O. V., Swanson S. D., Fokwkes J. B., Emelianov S. Yu.* Shear Wave Elasticity Imaging – a New Ultrasonic Technology of Medical Diagnostics. *Ultrasound in Medicine and Biol.* 1998. V. 4. No. 9. P. 1419–1436.
 11. *Sarvazyan A. P., Rudenko O. V., Nyborg W. L.* Biomedical applications of radiation force of ultrasound: Historical roots and physical basis (Invited Review). *Ultrasound in Medicine and Biol.* 2010. V. 36. No. 9. P.1379–1394.
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