



EFSUMB History of Ultrasound

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Ukraine (UA)

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Introduction

The development of ultrasound diagnostics (USD) in Ukraine began in the 70s of the 20th century. It is worth considering 2 fields: 1 - the clinical application of ultrasound (US) in medicine by doctors and 2 - technical, engineering solutions, which eventually led to the creation of modern domestic US devices with excellent B-mode, sensitive Doppler, all types of elastography and steatometry.

Clinical implementation of ultrasound

In the USSR in the clinic, the beginning of the use of US was laid in neurology in the 70s on the basis of the application of the A-method for visualizing the width of the 3rd ventricle of the brain and other intracranial structures - echoencephalography. The A-method is based on visualizing the amplitude modulation curve of ultrasonic wave reflections on the device screen. These reflections of various amplitudes occurred at the boundaries of tissues with contrasting acoustic impedance (skull bones, dura mater, brain matter and cerebrospinal fluid in the cerebral ventricles). US insonation was performed by transtemporal approach. The signal of the highest amplitude M-echo was obtained from reflections of the midline structures of the brain, located perpendicular to the US beam in the sagittal plane (third ventricle, pineal gland, crescent of the dura mater, pallid membrane, septum). In the case of an increase in intracranial pressure, the cavity of the 3rd ventricle expanded. In case of mass pathology, the displacement of the median structures of the brain relative to the signals from the skull and M-echo was assessed (a symptom of dislocation of the median structures). A-method of visualization with the Echoencephaloscope ЭЭС-01 device (USSR) was also used for abdominal visualization. It was first mastered in 1983 by Dr. Dynnyk O.B. at the Department of Internal Diseases No. 1 of the Bogomolets Kyiv Medical Institute and later, since 1985, used the B-mode on the Aloka SSD-256, Japan (Department of Clinical Pathophysiology, Kavetsky Institute of Experimental Oncology, National Academy of Sciences of Ukraine).

In 1981, the B-method began to be applied by the pioneers of US in Ukraine from the group of Professor Medvediev V.E. (fellow workers of the Laboratory of Functional Methods of Studying the Digestive Organs of the Kyiv Research Institute of Clinical and Experimental Surgery of the Academy of Medical Sciences of Ukraine (Director - Academician O.O. Shalimov). They used US devices with mechanical sector scanning - Aloka SSD-120 (Japan) and

linear electronic scanning - Aloka SSD- 630 (Japan). At the same institute, a group of doctors: Grigorash G.A. (head) and Hooch A.O. began to use Doppler for vascular examination (1987 - Pocket Dopp, 1991 - Ultramark 9 (ATL, USA) and Multi-Dop (Compumedics DWL, Germany).

Intervention

Prof. Medvedev' team for the first time in the USSR since 1983 applied methods of interventional ultrasound in solving problems, first of all, in abdominal surgery: Medvedev V.E. (leader), Tarasyuk B.A., Novikova M.M., Terzova T.B., Buchneva L.V (Figure 1).

Figure 1 Pioneers of ultrasound in Ukraine.



Since 1996 in Odessa doctor Boyko A.V. applied interventional methods of treatment of parasitic (echinococcus) and nonparasitic liver cysts under ultrasound control. Since 1993, a group of surgeons using interventional ultrasound began to work in the regional Donetsk diagnostic center - DDC (director BD Kolesnikov): Zubov O.D. (leader), Chirkov Yu.E., Belonenko G.A., Uspensky D.A., Cherednichenko S.I., Gubanov D.M (Figure 2).

Figure 2 A group of surgeons using interventional US at the DDC.



Professor Konjkova M.B. founded her school of interventional ultrasound in Donetsk. (Department of Oncology, Radiation Methods of Diagnostics and Treatment of Donetsk National Medical University) (figure 3).

Figure 3 Professor Konjkova M.B.



In Zaporizhzhya, the methods of intervention under the US control were actively introduced by Associate Professor Fedusenko O.A. (Department of Radiation Diagnostics of the Zaporizhzhya Academy of Postgraduate Education).

Endocrinology

In Kyiv, a group of doctors led by Professor Epshtein E.V. was engaged in the issues of US imaging of the thyroid gland and fine-needle puncture aspiration biopsy at the Research Institute of Endocrinology and Metabolism of the Academy of Medical Sciences of Ukraine. This direction developed especially intensively after the accident at the Chernobyl nuclear power plant in 1986. This event contributed to the intensive introduction of US, especially in the diagnosis of the state of the thyroid gland after exposure to nuclides of millions of Ukrainians. Then, soon, the intervention of the thyroid gland under the control of US was introduced in many cities of Ukraine (devices from Toshiba and Aloka (Japan), Siemens (Germany), GE (USA), B / K (Denmark), Kretz Technic (Austria)).

Pediatrics

Neurosonography began its development with the delivery of 20 devices to newborn departments in the cities of Ukraine - Microimager-1000 with sector sensors in 1987. The pioneers of neurosonography were the doctor Makarova O.O. ("OKHMATDET" hospital and then the Ukrainian Medical Center for the Rehabilitation of Children with Organic Damage of the Nervous System of the Ministry of Health of Ukraine) and Associate Professor Krygin Yu.A. (Department of Radiation Diagnostics, Shupik National Academy of Postgraduate Education). US of the thymus gland in pediatrics was developed thanks to the initiative of the professor of the Department of Radiology of Shupik NMAPE O.A. Gonchar and the chief radiologist in Kyiv Urina L.K. Rapid introduction was received by US of the hip joint in newborns and young children by the method of Graff (1985) modified by Research Institute of orthopedics and traumatology of the Academy of Medical Sciences of Ukraine (Vovchenko A.Ya., 1995). Fundamental achievements of pediatrics US were made by the team of the Research Institute of Pediatrics, Obstetrics and Gynecology of the Academy of Medical Sciences of Ukraine (Professor Lukyanova I.S.).

Musculoskeletal US

In Ukraine the development of the musculoskeletal US has led to the formation of several schools with leaders: in Kyiv - Vovchenko A.Ya., Urina L.K., Golovko T.S.; in Kharkiv - Abdullaev

R.Ya.; in Sumy - Gapchenko V.V., in Lviv - Kucher A.R. A special direction was US of the spine according to the method of Kindzersky A.Yu.

Oncology

The introduction of oncology US took place through the efforts of specialists from the Kyiv Research Institute of Clinical and Experimental Surgery of the Academy of Medical Sciences of Ukraine (Kyiv), the National Cancer Institute of the Ministry of Health of Ukraine (Kyiv), the Institute of Medical Radiology of the Academy of Medical Sciences of Ukraine (Kharkiv), Donetsk Medical University (Donetsk), etc.

Doppler

A team of doctors from the Romodanov Neurosurgery Institute, National Academy of Medical Sciences of Ukraine made a significant contribution to the development of US imaging methods in neurology and neurosurgery. Doppler research methods have been actively introduced since 1993 on the basis of the Functional Diagnostics Department of the Institute. First devices: Transcranial Doppler - "TC 2-64 EME" (Germany), "Sonomed 300" (Russia) and since 1995 - "Multigon 500M" (USA) with conventional Doppler, Transcranial Doppler and bilateral Transcranial Monitoring modes (doctors Globa M.V., Mikhalj A.V. and Vaschenko V.V.). Since the 2000s, the department has been equipped with duplex US diagnostic systems: "Sonoline G-50" (Siemens, Germany, 2003), "Toshiba Aplio MX" (Toshiba, Japan, 2015), "Toshiba Aplio 400" (Toshiba, Japan, 2018). Since 2015, intraoperative Doppler studies have been introduced for transcranial surgeries to turn off arterial aneurysms of the brain - contact microvascular Doppler with 16 MHz transducers (Angiodin PC, Bioss, Russia). In 1998, the Medical Scientific and Practical Association "Medbud" introduced conventional methods of duplex scanning of the vessels, and especially: kidneys, splanchnic vessels (diagnosis of renal and portal hypertension), HBR by HDI-5000 (ATL, USA). It introduced transcranial Doppler monitoring of cerebral blood flow and embolodetection by Angiodin ПК (Bioss, Russia). As well as TEE and stress echocardiography with dobutamine on the HDI-5000 apparatus (ATL, USA) (doctors Dynnyk O.B. (head), Korichensky O.M., Senatorova L.M. and Mostovoy S.E.

Cardiology

Professor Stadnyuk L.A. began to perform Echocardiography since 1979 using US machines of Smith Kline Instruments at the Strazhesko Research Institute Cardiology of the Academy of Medical Sciences of Ukraine (Kyiv). After then he worked on the US machines of ATL, Toyota, Kontron (Figure 4).

Figure 4 The pioneer of echocardiography in Ukraine - Professor Stadnyuk L.A.



Transesophageal echocardiography (TEE) in Ukraine was first introduced by doctors Ivaniv Yu.A. (Lviv), Beshlyaga V.M. (Amosov Institute of Cardiovascular Surgery of the National Academy of Medical Sciences of Ukraine, Kyiv). Professor Ivaniv Yu.A. heads the Department of Radiation Diagnostics, Faculty of Postgraduate Education, Danylo Galitsky Lviv National Medical University.

The school of the improvement of Doppler echocardiography and functional topographic anatomy of the heart according to the author's methods "ECHO 3P + 4C" and "3D TRIPLAN" was created by a native from the Cherkassy Cardiological Center, cardiologist Miroshnik M. (employee of the Hôpital Européen Georges Pompidou PARIS - France). He introduced original pedagogical techniques, including: virtual 3D modeling of the anatomy of the heart, navigation on the echosimulator.

Dobutamine stress echocardiography has been actively implemented into routine practice since 2004 at Medical center "Medbud" (cardiologist Mostovoy S.E.) and in 2007 at the Heart Institute of the Ministry of Health of Ukraine (Kyiv). The pioneer of the method of myocardial

deformation analysis (Strain Rate) is associate professor Molodan O.V. of the Zaporizhzhya Academy of Postgraduate Education.

Obstetrics and gynecology

The introduction of US in obstetrics and gynecology practice began in 1993 by Corresponding Member of the Academy of Medical Sciences of Ukraine, Professor Grechanina E.Yu., being the head of the Department of Clinical Genetics and Ultrasound Diagnostics at Kharkiv Medical University.

In the Interregional Center of Medical Genetics and Prenatal Diagnostics (Kryvyi Rig, Dnepropetrovsk region), for the first time in Ukraine in 1980, genetic amniocentesis was performed and prenatal diagnostics of chromosomal abnormalities in the fetus was started by the pioneer of US in prenatal diagnostics Veropotvelyan M.P.

At the base of the Kyiv Regional Hospital, in early 1983, he performed amniocentesis in the third trimester of pregnancy to determine lung maturity in the fetus using Aloka SSD-202 (Japan) in order to select a safe puncture approach. After 1.5 months training on US in obstetrics and gynecology in the laboratory of Professor Demidov V.N. at the All-Union Center for Maternal and Child Health (Moscow) in 1984. Veropotvelyan Mykola began to widely practice echography at the City Maternity Hospital No. 1 and the Interregional Medical Genetic Center in Kryvyi Rig. The first US scanners were Toshiba SAL-35 and SAL-77 (Japan), and for invasive prenatal procedures portable devices Medata ADR 2002 (USA) Toshiba SAL-32B Dr. Veropotvelyan M. has mastered and implemented the entire arsenal of invasive fetal procedures performed under ultrasound control - amniocentesis, transcervical and transabdominal chorionic villus sampling, cordocentesis, cardiocentesis, aspiration of fetal cysts and intrauterine blood transfusions. Today Veropotvelyan M.P. is the General Director of the Interregional Center for Medical Genetics and Prenatal Diagnostics in Kryvyi Rig and a teacher for many young professionals (Figure 5).

Figure 5 Prenatal screening is carried out by Dr. Veropotvelyan M. (a). Amniocentesis under ultrasound guidance in Interregional Center for Medical Genetics and Prenatal Diagnostics in Kryvyi Rig (b).

a



b



Ian Donald's school was held in Ukraine twice, the last time in February 2020.

Urology and lithotripsy

On 09.07.1990, a lithotripsy room was opened in the Donetsk Diagnostic Center (DDC, director B.D. Kolesnikov). Lithotripter MPL-9000 manufactured by Dornier Medizintechnik GmbH was used by a team of medical and engineering personnel trained and certified in clinics Stuttgart, Munich, Ulm (Germany). Doctors urologists Reznikov D.B., Roshchin Yu.V., Fedorishin R.P., Reznikov G.D. mastered the basics of US navigation in lithotripsy and biopsy. Since 2007, shock

wave lithotripsy has been performed on the “Modulith SLK” lithotripter by “Storz Medical” (Switzerland). The ultrasound scanner Aloka SSD-1000 (Japan) and the X-ray apparatus "BV Libra" (Philips, Holland) are used for navigation.

Transperineal prostate biopsy in DDC was performed from 1992 to 1994 on the Aloka SSD-630 device (linear sensor). Transrectal prostate biopsy has been performed since 1994 on devices: Dornier AI 2200 and Aloka SSD-3500, equipped with a rectal probe. Kidney biopsy under US control in adults and children is widely introduced by the doctor Chirkov Yu.E. in hospitals in Donetsk and Kyiv. Today, prostate biopsy is performed with Fusion technology in ten hospitals in Ukraine (mentor Solodovnik O.V.).

Elastography

Significant development of methods of US elastometry and steatometry became possible in Ukraine due to the development and production of Ukrainian US devices with these innovative technologies (firms "Radmir" and "Ultrasign", Kharkiv) (Figure 6).

Figure 6 The team of developers of elastography and steatometry from “Radmir” and “Ultrasign”, headed by chief designer Marusenko A.I. and doctor Linska G.V.



Experimental elastography studies on rats and pigs were carried out by different groups. We used Ukrainian ultrasound devices (Radmir, Ultima SM and Ultrasign, Soneus P7) for shear wave elastography (SWE) in modeling cirrhosis, fatty liver disease and Guerin's tumor [1-6]. There were collectives of the Department of Clinical Pathophysiology of the Bogomolets Institute of physiology of the Ukrainian National Academy of Sciences, the Division of

Endocrinology, Bogomolets National Medical University; the National Cancer Institute of the Ministry of Health of Ukraine (Kyiv), Shevchenko National University (Kyiv).

Education

Physicians have been trained in the basics of US diagnostics 1981 in the Laboratory of Functional Methods for the Study of the Digestive System of the Research Institute of Clinical and Experimental Surgery of the Academy of Medical Sciences of Ukraine (Chief - Professor Medvediev V.E., employees Tarasyuk B.A., Novikova M.M., Terzova T.B., Buchneva L.V.). The systematic teaching of US diagnostics was laid in Kyiv at the Department of Radiology of the Shupik National Academy of Postgraduate Education (head of the department - Professor Koval G.Yu., the course was conducted by Prof. Gonchar A.O., associate professors Yatsyk V.I. and Krygin Yu.A.) since 1989. Now it is the Department of Radiology (head professor Babkina T.M., head of the US course professor Medvediev V.E., teachers - professor Kazarenko T.M., associate professors Volyk N.K., Gladka L.Yu., etc.).

The history of education in the field of US diagnostics in Kharkiv began in 2000, when Professor Abdullaev R.Ya. began teaching the fundamentals of US diagnostics for interns of the Department of Radiation Diagnostics of the Kharkiv Academy of Postgraduate Education (KhMAPO). In 2008, Professor Abdullaev R.Ya. created the first and so far the only Department of US Diagnostics in Ukraine at KhMAPO (Figure 7).


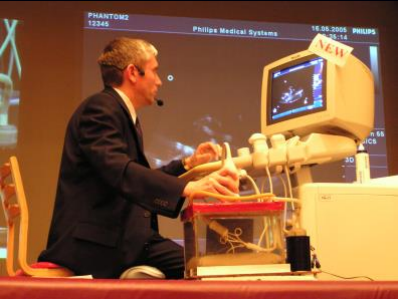

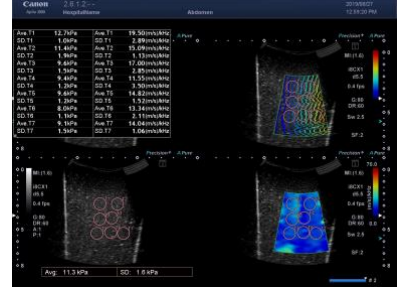


Figure 7 Professor Abdullaev R.Ya.



The teachers of the US Department are associate professors Kalashnikov V.I., Sysun L.A., Ponomarenko S.A. and others. Recently, the staff of the department has been working a lot in the direction of improving Doppler methods in the diagnosis of pathology of various organs and systems. In particular, the latest research diagnostic methods for vertebral arteries and cerebral veins, a comprehensive assessment of the state of vascular regulation in various neurological and cardiovascular diseases have been introduced into clinical practice. A special stimulus to the development of multimodal thinking of US doctors in Ukraine was played by the help of the m “Friends of Radiologists of Ukraine” group from the Ukrainian diaspora of the USA and Canada. They are members of RSNA (O. Baltorovich, L. Volyansky, M. Poznyak, B. Pollard, etc.). At the suggestion of O. Baltorovich, in the 90s, several ultrasound doctors were trained at the Education and Research US Institute (director Professor Barry Goldberg) of the Jefferson Philadelphia University (Pennsylvania, USA). Doctors of this group in Ukraine have become leaders in the areas of US diagnostics (Ivaniv Yu.A. - TEE, Volyk N.K. - gynecology, Serdyuk V.O. - endocrinology).

With the aim of teaching the basics of ultrasound in Ukraine, phantom simulators of an original design were created: for ultrasound intervention (Zubov O.D. and colleagues), for Doppler (Dynnyk O.B.), for elastography (strain and shear wave elastography) (Dynnyk O.B., Zhaivoronok M.M.) and a multiparametric/multimodal phantom for US elastography, steatometry and evaluation of tissue viscosity of the liver and MR steatometry (PDFF) (Dynnyk O.B., Solodovnik O.V, Omelchenko O.M.). Studies were carried out on devices Canon Aplio i800, Japan (2D SWE, Propagation, Share Wave Dispersion (SWD), Attenuation Coefficient (AC)) and Ultrasign Soneus P7, Ukraine (2D SWE, 2D Attenuation Coefficient Measurement (ACM)) (Figure 8).

Figure 8 Different phantoms for interventions, Doppler and multiparametric imaging.

		
<p>Intervention US Phantom (a)</p>	<p>Doppler Phantom (b)</p>	<p>3D Angio of the Doppler Phantom (c)</p>
		
<p>Multiparametric liver phantom: 2D SWE, Propagation, SWD, AC by Canon Aplio i800 Liver Package (d)</p>	<p>ACM by Ultrason Soneus P7, Ukraine (e)</p>	

The Ukrainian Association of Ultrasound Diagnostics Specialists (UAUDS)

The Ukrainian Association of Ultrasound Diagnostics Specialists (UAUDS) was registered on May 29, 1998 (No.1032) as an all-Ukrainian public organization. The initiative group of US doctors of various directions included Medvediev V.E., Sopko S.O., Gordienko E.Yu., Klimenko O.F., Tarasyuk B.A., Dynnyk O.B., Novikova M.M., Golovko T.S., Lukyanova I.S., Dugan I.V., Volyk N.K., Pogodaeva G.A., Globenko T.A., Slobodyanyuk I.M. The first president of UAUDS is Professor Medvediev V.E., and from 2004 until today – Dynnyk O.B. In April 2006, on the basis of an agreement, UAUDS became an Associate member of the Association of Radiologists of the Ukrainian (ARU), and UAUDS members thus joined the European Society of Radiologists (ESR). Ukrainian US specialists became active participants in radiological meetings and congresses in Ukraine and the European Congress of Radiology (ECR). On May 29, 2019 UAUDS became a member of EFSUMB (President - Dynnyk O.B., Secretary - Bekalo I.S., Treasurer - Zhayvoronok M.M.).

With the aim of widespread introduction of the US Doppler among doctors in Ukraine, an initiative group (Dynnyk O.B., Hooch A.O., Korichensky O.M., Kalashnikov V.I., Linska G.V., Slobodyanyuk I.M., Globa M.V., Dugan I.V.) in 2000 the Ukrainian Doppler Club (UDC) was established. Members of the Russian Doppler Club provided great support in the implementation of Doppler technologies. The first president of the UDC is Dynnyk O.B., and from 2004 until today - Hooch A.O.

Development of US medical technologies and US instrumentation in Ukraine

The development of US technologies and the creation of equipment for medicine in Ukraine occurred thanks to the work of 3 groups of Ukrainian engineers and scientists from Kyiv ("Eskulap-UST" Ltd, "Exim Ltd") and Kharkiv (firm "Radmir", Department of Nuclear and Medical Physics of the Physics-Technical faculty of Karazin Kharkiv National University, "Ultrasign Ltd").

A team of US developers and engineers from Kharkov

Since 1980, in Ukraine, research in the field of application of US technologies in medicine has been carried out at the School of Physics and Technology of Kharkiv State University named O.M.Gorkiy (now V. N. Karazin Kharkiv National University, KhNU). Despite the insufficient state funding in the USSR of developments on the creation of modern US medical equipment, this line of research was very promising and relevant. The reason is that in the medical clinics of the USSR, US medical equipment was practically absent, while in Western Europe, the USA, Japan and others it has already become widespread and has proven its high diagnostic efficiency. Research at KhNU concerned acoustic bio effects [11], ultrasound transducer [12], as well as the possibility of using harmonics of ultrasonic radiation and nonlinear waves of combination frequencies for medical diagnostics [13, 14]. Currently, research on medical US is being carried out at Department of Medical Physics and Biomedical Nanotechnologies.

One of the leading enterprises for the development and production of space technology in the USSR was the Research Development Institute of Radio Engineering Measurements (RDIREM), Kharkiv. In the early 90s, after the collapse of the USSR and the deterioration of funding for the space industry, RDIREM was forced to look for ways to preserve and develop its scientific

potential, highly qualified personnel and science-intensive technologies. An area related to the development and serial production of complex electronic medical equipment was also chosen as an alternative promising direction. At the same time, cooperation in the field of medical applications of US between RDIREM and KhNU began, which laid the foundation for further equal partnership between engineers, physical scientists and clinicians.

In 2005, a group of engineers from RDIREM headed by Marusenko A.I., who were directly involved in the development of US diagnostic equipment, became a division of "RADMIR" Company, a subsidiary of RDIREM, specializing in the development, manufacture and sale of medical equipment. RADMIR has prepared and launched into serial production a range of US medical devices with electronic scanning from portable to expert class devices. In 2014, the same group of engineers, with the participation of the Makena Medical AG Company (Switzerland), founded a new company Ultrasign Ltd (Kharkiv, Ukraine), which is engaged in the development and implementation of US diagnostic technology in clinical practice.

Diagnostic devices

1992 was the year of release of the first Ukrainian ultrasound diagnostic machine with mechanical transducers, developed in RDIREM, and in 1996 a prototype of a digital system with electronic scanning and a linear ultrasonic transducer was manufactured. After that, diagnostic scanners were mass-produced: ТИ-628А, ТИ-628М, Radmir M, ULTIMA Pro-10, ULTIMA Pro-30. As well as the diagnostic scanner ULTIMA PA Expert, which has all modern diagnostic and imaging modes and has a wide range of clinical applications (multibeam scanning, second tissue and inverse harmonics, 3D and panoramic scanning, elastography family, Doppler technologies (CDF, PDF, directed PDF, CFM of pulsating flow, Dynamic Flow, tissue Doppler (CFM, M-mode, spectrum-mode)).

Subsequently, Ultrasign Ltd developed and launched into serial production the US diagnostic scanner Soneus P7 of low weight (13 kg), in which, along with all conventional diagnostic modes, technologies of 2D shear wave elastography and real-time elastometry, Strain elastography (Active and Natural Strain) and technology for calculating the Attenuation Coefficient Measurement (ACM) in soft tissues (in particular for quantitative staging of hepatic steatosis) (Figure 9).

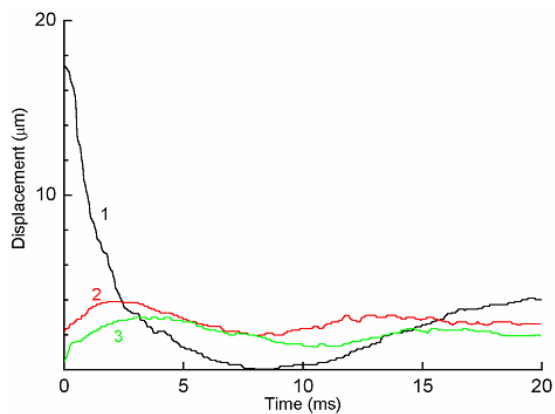
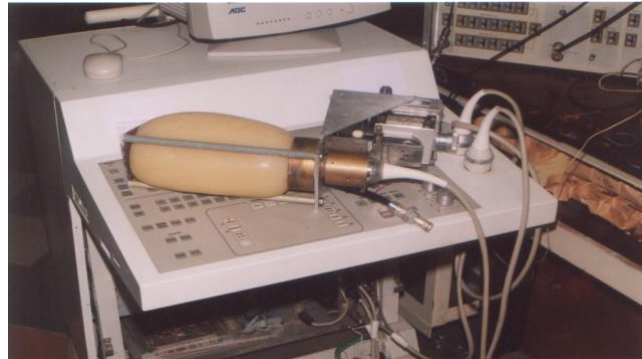
Figure 9 The first Ukrainian ultrasound diagnostic scanner TI-628 (a), diagnostic scanner ULTIMA PA Expert (b) and Soneus P7 (c).

**a****b****c**

Shear Wave Elastography / Doppler

At the first stage of cooperation between KhNU and RDIREM, the goal was to theoretically and experimentally study the characteristics of the ultrasonic Doppler response of biological objects for further development and implementation of Doppler diagnostic modes in Ukrainian US diagnostic scanners. The results of these studies and references to earlier works concerning US Doppler since 1992 are given in [15]. The studies carried out made it possible to optimize the parameters of pulsed and continuous-wave Doppler diagnostic modes in Ukrainian diagnostic devices (Figure 10).

Figure 10 Temporal behavior of the shear displacement at various locations within the focal plane (a) recorded with a usage of modified scanner ТИ-628А and soft tissue ultrasound phantom (b)



a

b

At the same time, physicists from the School of Physics and Technology, headed by Barannik E.O., were also looking for ways to determine the viscoelasticity properties of biological objects, which could be very effective for diagnosing a large number of soft tissue pathologies. In 1998, the first joint research project between KhNU and ArtannLabs Inc (NJ, USA, director Sarvazyan A.P.) began, in the course of which the possibility of ultrasonic Doppler recording of soft tissue movement during the passage of a shear wave, as well as the ability to determine using SWE is the value of Young's modulus based on the shear wave propagation velocity [16, 17]. These studies were carried out in cooperation with RDIREM, which prepared a modified version of the commercial US scanner TI-628A, with the help of which all experimental studies related to SWE were carried out at KhNU. Unlike the American group of physicists headed by K. Nightingale, who also developed the method of US elastography within the framework of

the ARFI (Acoustic Radiation Force Impulse) technology [18] using speckle-tracking, the Ukrainian scanner TI-628A used the original phase tracking method (phased tracking) for precise determination of the magnitude of tissue movement and blood flow rate. During the next joint research with ArtannLabs Inc, experiments were carried out with soft tissues in vitro to determine the effect of viscosity on the magnitude of tissue displacement and the speed of shear waves [16, 19]. At the final stage of joint work with ArtannLabs Inc, a prototype of a portable ultrasonic Doppler motion detector with A-line mode was manufactured, which was successfully tested at ArtannLabs Inc. The results of the research were intensively discussed during several visits by Barannik E.A. to Sarvazyan A.P., Chief Scientist of ArtannLabs Inc, and were also presented at conferences NOISE-CON 2000, USA, "Ultrasonics International 2001", Netherlands, and 5th World Congress on Ultrasonics WCU 2003, France.

In experiments in vitro and especially in vivo, carried out to create a version of SWE, suitable for clinical implementation, an essential contribution was made by Linska G.V., who worked as a researcher at the Institute of Neurology, Psychiatry and Narcology of the National Academy of Medical Sciences of Ukraine.

As a result, in 2011, just a year later than the French company SuperSonic Imagine, firm RADMIR released the first Ukrainian commercial scanners with 2D SWE technologies and colour mapping of soft tissue elasticity distribution.

Ultrasound Attenuation Coefficient Measurement (ACM)

During the 2010s, several research groups around the world have been involved in improving methods for measuring ultrasound attenuation in soft tissue. This interest is due to the fact that staging of hepatic steatosis is extremely important. Non-alcoholic fatty liver disease (NAFLD) has become a pandemic, affecting up to 30% of the population. NAFLD is an independent predictor of the development of cardiovascular and cerebrovascular accidents. In accordance with this, Ultrasign Ltd engineers in collaboration with physicists from KhNU have developed an original method for measuring the attenuation coefficient [20] and colour mapping of the attenuation coefficient distribution, which are successfully used now in clinical practice not only in Ukraine.

"Eskulap-39 Ltd" / "Eskulap-UST Ltd"

"Eskulap-39 Ltd" and later "Eskulap-UST Ltd" was born in the bowels of the Kyiv Research Institute "GidroPribor", which was created in Soviet times for the development of hydro acoustic equipment for military purposes. In 1996, under the leadership of the director V.V. Yaroshenko (now director Bykova O.T.) the team of "Eskulap-39" Ltd has created an US device with four line-scanning probes of its own production for studies of abdominal organs, obstetrics and gynecology, urology, as well as superficial organs - "USDS-05" (Figure 11).

Figure 11 US apparatus "USDS-05" (a). The first director and founder of "Eskulap-39" Ltd, Yaroshenko V.V. (b).

a



b



The creation of original domestic ultrasonic probes was the result of the R&D "Flora" in 1991. This was especially important in connection with the growth of tumors of the thyroid and mammary glands after the Chernobyl accident. "Eskulap-UST" Ltd (designers Bykova O.T., Boyko V.F. and others) produces special phantoms for metrological verification of Doppler modules and the resolution of the B-mode of US devices: "Measure of blood flow velocities - MCK-03" and "Measurer of acoustic lengths - МАД-05". By order of the President of the UDC Dynnyk O.B., at "Eskulap-UST" Ltd, he created a training simulator - a Doppler phantom with three-dimensional reconstruction of vessels and presentation of the main Doppler phenomena in angiology: stenosis, aneurysm, deviation, turbulence, aliasing, redistribution, collateral blood flow. "Eskulap-UST Ltd" since 1993 and up to now has been producing domestic "Gel contact" for US.

"Exim Ltd"

The third group of developers and creators of equipment for US diagnostics was the team of "Exim Ltd" (since February 2002). In collaboration with developers from Vilnius (Lithuania), a series of portable (hand-held US device) US devices was created - SonoFly-3000, SonoFly-3000M, incl. and for general practitioners (family doctors) and for telemedicine in 2003. These US devices were built on the basis of WINDOWS (first 98, and later XP) and used standard operating system tools for remote control and/or information transfer. The interface of the US devices was controlled remotely with a mouse or trackball. The RemoteAdmin program completely transferred the remote screen, mouse, keyboard to the doctor-consultant's computer. This program is the predecessor of today's TeamViewer.

The SonoFly-3000 device has passed clinical trials in the Regional Clinical Hospital and Central District Hospital (Kolomyia), in the Rivne Regional Clinical Diagnostic and Treatment Center, and in the Zhytomyr Regional Consulting and Diagnostic Center. As a result, the SonoFly-3000 device was recognized as ready for implementation for conducting US telemedicine consultations.

Conclusion

The development of US diagnostics in Ukraine is directly related to the development of world US technologies. All the most modern US technologies and equipment are now available to doctors in Ukraine. An important and crucial point is the mastering of knowledge and skills by doctors for the most effective use of this equipment. An important fact is that UAUDS became a member of EFSUMB. This event led to an intensive exchange of information and opened up opportunities for doctors in Ukraine to honorably respond to the challenges of the time. In particular, this illustrates the instant implementation of the protocols for US of the lungs and the issues of safe conduct of US by WFUMB / EFSUMB in the conditions of COVID-19 by Ukrainian doctors.

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