EFSUMB Newsletter

European Federation of Societies for Ultrasound in Medicine and Biology

Warming up to Sydney in 2009

In April 2008 the President-Elect of Australasian Society for Ultrasound in Medicine (ASUM) Professor Ron Benzie was in Copenhagen as a guest lecturer as part of the collaboration between DSDU and ASUM. We will probably hear a lot from Ron Benzie and our friends from Australia and New Zealand in the Newsletter in the next year leading up to the next world congress in Sydney in 2009.

For those who forgot, the 12th World Congress of the World Federation for Ultrasound in Medicine and Biology will be held in Sydney Convention & Exhibition Centre, Sydney, Australia 30 August - 3 September 2009. Website http://www.wfumb2009.com

Legend for the image: Ron Benzie (right) and Michael Bachmann Nielsen in Copenhagen April 2008

Ron Benzie is also the Editor of the ASUM Bulletin, which can be found at the ASUM website http://www.asum.com.au

Comment on New Technology - Ultrasound Elastography

Jeffrey C. Bamber

Ancient cultures extending back many thousands of years used palpation to assess the mechanical properties of tissues, and thus detect and characterise disease or injury. Hippocrates, for example, is reported to have advised that the first issue to address when presented with a patient who has sustained a head injury is locating the wound and determining whether the cranium underneath is strong or weak. Palpation was used to determine "whether the bone is denuded of flesh or not." The ancient Egyptians, for example, also used palpation; the technique is mentioned in the Edwin Smith Papyrus, the world's earliest known example of medical literature, dated around 1900BC.

Simple palpation continues to be of value in modern medicine, both practised by doctors and as a technique for self-examination, but palpation is limited to a few accessible tissues and organs, and the interpretation of the information sensed by the fingers is highly subjective. Ultrasound elastography aims to display images that are related to a broad range of parameters that describe the spatial and temporal variations in tissue viscoelasticity. It does so by processing time-varying echo data to extract the spatial and/or temporal variation of a stress-induced tissue displacement or strain. There is a range of signal processing techniques for extracting the tissue displacements or strains, such as searching for the peak of the cross-correlation between two echo patterns, seeking the time shift that maintains zero phase change, or even measuring the phase change itself, which is Doppler. There are many ways of applying the stress (force), and there are many approaches to extracting properties for image display. The variations combinations and refinements of these possibilities provides ample opportunity for ongoing research, much of which is discussed each year at the International Conference on the Ultrasound Measurement and Imaging of Tissue Elasticity, now in its 7th year, with past proceedings available on the web site http://www.uth.tmc.edu/schools/med/rad/elasto/conference/.

In recent years the method of elastography, in an early form, has emerged as an option on a number of commercial ultrasound systems, and is starting to prove clinically valuable in many areas, particularly for example in assisting breast cancer diagnosis, or in guiding minimally invasive treatment of prostate disease. This is a key moment in the success of any new technique, where the method may be evaluated by new users outside of the laboratories in which it was developed, and elastography is performing well. Reports at major conferences such as RSNA and ECR are coming from groups achieving successes that confirm earlier studies carried out by those more experienced in elastography, in using it as an adjunct to conventional ultrasound for improving the assessment of breast abnormalities.

The history of the development of ultrasound elastography did not jump from palpation to where we are now with commercial implementation; this transition has taken place over a 30 year period, with contributions from workers in France and Belgium during the 1970s, who pioneered the assessment of tissue stiffness by observation of M-mode features during palpation, then European and Japanese who did the same for B-mode "dynamic features" during the 1980s, followed by workers from various countries during the 1980s who developed algorithms for processing ultrasonic echoes for the measurement of tissue displacement, and eventually of strain or strain-rate during the 1990s. The current commercially available "freehand elastography" derives its name from the use of a hand-held ultrasound transducer to induce tissue strain by applying gentle pressure to the surface of the body, or to use internal cardiovascular pulsations as the source of stress, while the system displays either a grey-scale image of tissue strain alongside the conventional echo image, or the two are combined using a colour overlay for strain. The term freehand elasticity imaging was first used by the author in 1996, and arguably the first elasticity image made in this way was shown at the annual conference of the American Institute for Ultrasound in Medicine in 1988.

The usefulness of elastography, even in its present form, is likely to improve quite quickly, as we learn to take advantage of the information that it provides and as new technology allows it to move into three dimensions, which will have a substantial impact on the quality of elastograms as well as ability to interpret elastographic artefacts. Nevertheless, in its current form it would remain a strongly subjective technique and would continue, as with palpation, to require interpretive skills to be learnt. There are good reasons to believe that a more quantitative and objective analysis will lead to clinically more valuable measures of tissue composition, function or state, with images that are easier to interpret. This is where the future of elastography is leading, employing advanced models of tissues and their mechanical behaviour to convert strain data to images of tissue properties such as shear modulus, compressibility, nonlinearity, anisotropy, friction at mechanical discontinuities, as well as properties that determine viscoelastic and poroelastic behaviour (related to microvascular and interstitial fluid flow). It is tempting to consider that some of the dreams past, of the subject of tissue characterisation, may yet come to fruition.

An important subgroup of such advanced methods makes use of shear wave propagation. Conventional echography uses ultrasound, which travels mostly as a longitudinal wave. The mechanical properties mentioned above are governed by the shear properties, especially the shear modulus, and a measurement of the speed with which a shear wave propagates provides quite a direct measurement of the shear modulus. Because shear waves in soft tissue travel about one thousand times slower than longitudinal waves, ultrasound images can be used to observe the passage of a shear wave and hence its speed, so long as the ultrasound echoes can be generated frequently enough. One commercial device has already existed for a number of years that uses such concepts to characterise liver disease; a "thumper" on the surface of the abdomen launches a shear wave into the body and ultrasound A-scans (at thousands of repetitions per second) are used to measure its speed of propagation in the liver, which is strongly related to degree of fibrosis. Advanced (parallel receive) electronics is now making it possible to acquire whole echograms at thousands of frames per second, so that it is possible to make full images of the shear modulus. Alternatively, it is possible to "slow down" the shear waves, by having two interfering continuous shear wave fields generated by vibrating sources, so that even a conventional scanner can be used to follow their motion.

A final option in the current "bag of tricks" is to generate the stress using ultrasound radiation force. A short burst of highly focused ultrasound creates a small (few tends of microns) transient displacement of the tissue, which can be detected using the kinds of echo signal processing employed in elastography. This can potentially be used create elastograms of deep or fast-moving tissue, such as the heart or liver, or even tissue beyond rigid obstructions such as the skull. Two commercial manufacturers are due to release products of this type later in 2008. Meanwhile, research in elastography seems set to continue to gain pace, building on the technical and clinical success to date.

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Recent progress in diagnostic ultrasound techniques

Norbert Gritzmann and David H Evans

The introduction of multi-row technology has revolutionized computed tomography in the past few years. Fast sequences, high SENSE factors and strong gradients have improved MR substantially. This has led to new indications for both techniques, as for example in cardiac imaging. Has similar progress occurred in ultrasound imaging? The answer to this question must surely be yes, the improvements may not appear as revolutionary as in CT or MR, but there is little doubt that giant strides have been made in ultrasound technology and that the resultant images are constantly improving and contributing more diagnostic information. In what follows some new applications of sonography are evaluated.

Ultrasonic Contrast Agents (UCAs) and Contrast Enhanced Ultrasound (CEUS) CEUS and the liver

The liver is at present the main target organ for CEUS (1), but an adequate image quality before contrast enhancement is a prerequisite. Modern ultrasound machines with sophisticated signal processing techniques can use very low mechanical index pulses which do not disrupt the shells of the UCAs and thus allow excellent visualisation of the vascular system. The evaluation of blood flow kinetics using ultrasound is at least equal to that of CT and MR since continuous visualisation of the contrast agent is possible, and because ultrasonic contrast agents remain within the intravascular space. Furthermore it is possible by the use of relatively high intensity pulses (still within the diagnostic range) to destroy the agent in a particular region and watch the reperfusion of that region. UCAs are used in many centres for the routine differentiation of focal liver lesions(2,3). In the case of malignant lesions of the liver, more lesions are visualised with than without the use of UCAs, and in the late phase an accurate differentiation of benign and malignant focal liver lesions is possible, comparable to that obtained with multi-detector CT(4). Also the therapeutic effect of radiofrequency ablation of tumours can be and should be monitored with UCAs.

CEUS and the heart

One of the most important uses of UCAs is echocardiography. It has many roles such as improving endocardial border definition, evaluation of shunts and regurgitation, imaging of myocardial perfusion, and assessing coronary arteries and coronary blood flow reserve.

CEUS and other organs

Although mainly used in the liver, UCAs have a developing role in the pancreas, kidney and spleen. A potential new application is in the differentiation of tumours of the pancreas(5). In particular, hypervascularized endocrine tumours can be recognized as being strongly supplied with arterial blood. Even proof of avascular necrosis in pancreatitis might be possible using UCAs. Traumatic parenchymal lesions in the liver, spleen and kidneys can be visualised substantially more accurately than in native scans. Liver, spleen and kidney infarcts can be diagnosed far better than with standard imaging(6), and focal nephritis can also be visualised with UCAs. Another potential application might be the evaluation of complex cystic lesions in the kidneys. UCAs are also useful in the assessment of urinary reflux in children.

In the arterial system the differentiation between complete occlusion and subtotal stenoses, which can be crucial in deciding upon therapy, particularly in the carotid arteries, will become a new indication for the use of UCAs. In small parts applications inflammation can be visualised with high sensitivity using UCAs. Rheumatoid arthritis may be diagnosed during the early soft tissue phase of the disease.

Particularly exciting is the prospect of molecular imaging with UCAs (7). Work is continuing on the development of agents that target, amongst other things, tumours, thrombus, the reticuloendothelial system, inflammation, and the lymphatic system Perhaps even more exciting is the potential for therapy using UCAs by the local selective release of drugs from UCAs using ultrasound pulses. Bubble destruction can be achieved using only diagnostic intensities, and indeed it is important in many applications to keep the ultrasound intensity relatively low so as not to inadvertently destroy the contrast agent.

Limitations of CEUS

In general the skill level required to use CEUS exceeds that required for native ultrasound examinations as the investigator requires extra knowledge of contrast agents, the kinetics of contrast agents and the vascularisation of tumours. The method is also more time consuming, and of course to some degree negates one of the greatest advantages of ultrasound, its complete non-invasiveness.

Another issue with UCAs has been the unwillingness of the different health care systems, financed through the public purse or through insurance companies, to finance the additional costs of these agents. In the liver, pancreas, liver, spleen and kidneys contrast agents are obligatory in CT and MR studies, so it is difficult to understand why ultrasound is singled out in this way when it can provide therapeutically relevant information in many situations.

Broadband transducers and harmonic Imaging

Important progress has been made in transducer design such that broadband transducers are commonplace. They allow the ultrasonic interrogation frequency to be optimised for the scanning depth; high frequencies close to the transducer to give the best possible resolution, and lower frequencies from deep structures to optimise the signal to noise ratio. Tissue harmonic imaging and its variants such as pulse inversion harmonic imaging which require broadband transducers to receive both the fundamental and harmonic frequencies have become standard in many applications. These techniques increase the contrast of lesions, and some artefacts are reduced, but have the disadvantage of being limited to shallower depths. Many high-end ultrasound machines now use pulse encoding to provide better penetration at a given frequency, or an increase in frequency for the same penetration depth.

Volume acquisition techniques

Due to the great computing power of modern ultrasound machines it is possible to quickly acquire 3-D and even 4-D data sets. In obstetric ultrasound, where the presence of amniotic fluid makes segmentation very easy, 3-D is very popular, and it is becoming more widespread in cardiology applications; in radiology however the real indications are far rarer. The demonstration of lumps in the breast, and the reconstruction of frontal planes can provide additional information. The optimization of ultrasound guided biopsy in real-time using 4-D ultrasound can be advantageous as the the location of the needle tip can sometime be better appreciated than in 2-D ultrasound. Also volumetric scanning of the thyroid gland provides better volume estimation, and similar techniques might be of advantage in comparing tumour volumes.

Compound scanning techniques

Whilst tissue boundaries do not act as perfect specular reflectors, the energy returning from a boundary tends to fall off away from the normal, and therefore it can be advantageous to interrogate lesions from different directions and combine the information thus obtained. This can result in a better delineation and detection of lesions(8), but may also reduce diagnostically useable artefacts such as posterior shadowing. Also the frame rate of the real time image is reduced.

Elastography

Another emerging field is that of elastography, where ultrasound is used to produce maps of the compressibility or elasticity of regions of tissue. This is being clinically evaluated as a means of detecting and differentiating lesions in the breast, prostate, thyroid gland and liver amongst other organs (9,10,11). There is a more detailed discussion of elastography elsewhere in this newsletter.

Portable Devices

A major trend in diagnostic ultrasound has been towards miniaturization, and there are now many machines available which are comparable in size to laptop computers. Some of these machines produce excellent images, although they do not include all the facilities available on a standard cart-based machine, and are particularly useful when it is better to take the ultrasound machine to the patient rather than visa versa. Thus these machines are particularly useful in critical care and emergency departments, but are also finding their way into many other hospital departments, where they are used for simple tasks such as image guidance for the placement of central venous catheters, for venous access lines and for nerve blocks, and for simple imaging tasks such as diagnosis of cholecystolithiasis, urinary obstruction, and cysts.

One concern regarding the new small portable (and inexpensive) machines is that they are finding their way into clinical environments where the users are not imaging experts. It is clearly vital that proper training is given to practitioners wishing to use such instruments even for relatively straight forward tasks.

Panoramic techniques

These serve as a clear way of demonstrating and documenting pathologies but do not aid the diagnostic process greatly(12).

New clinical application areas

A number of new clinical applications of sonography have been introduced in the past few years. A particularly interesting innovation is the diagnosis of peripheral nerve entrapment syndromes (for example carpal tunnel syndrome). Superficial nerves can be visualized with superb resolution ultrasonically, and the modality can be useful for assessing traumatic nerve lesions. The ultrasonic guidance of peripheral nerve blocks is becoming routine in many centres, and the guidance of radiofrequency ablation of tumours is frequently performed. Small parts and superficial imaging can produce stunning images through the use of higher and higher frequencies. The dynamic investigation of joints and tendons has suggested new indications in sports medicine and rheumatology. In superficial tissues, ultrasound can be regarded as the gold standard for differential diagnosis of lymophadenopathies. Detection and imaging of flow in both peripheral and central vessel has become substantially more sensitive and artefact free.

Finally the use of high intensity focussed ultrasound (HIFU) for the destruction of tumours is undergoing clinical trials in several centres.

Other considerations

One of the draw backs of ultrasound is that it remains highly examiner dependent. The practitioner scanning the patient usually has to make a diagnosis directly during the examination. A retrospective evaluation and/or a second opinion is much more difficult than with other imaging procedures. Real-time scans are not usually recorded although longer digital video loops could help to solve this problem, and the capture of complete 3-D data sets could allow examiners retrospectively to carry out virtual scans. Because of the unusual examiner dependence of ultrasound it is particularly vital that ultrasonic practitioners remain abreast of both clinical and technological developments, and it is hoped that industry will continue to support education and training initiatives to ensure ultrasound practitioners perform at the highest levels thus supporting the continued growth of the technique.

Although the need for the practitioner to spend time with the patient at the bedside is often considered a disadvantage, it also has advantages in that it leads to good intensive physician-patient communication which is highly appreciated by most patients and can often be of considerable benefit.

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EFSUMB Newsletter meets Italy

Facts:

- Area: 301.318 km2
- Population: 59.3 million
- Largest cities: Rome (2.7 million), Milan (1.3 million), Naples (975,000)

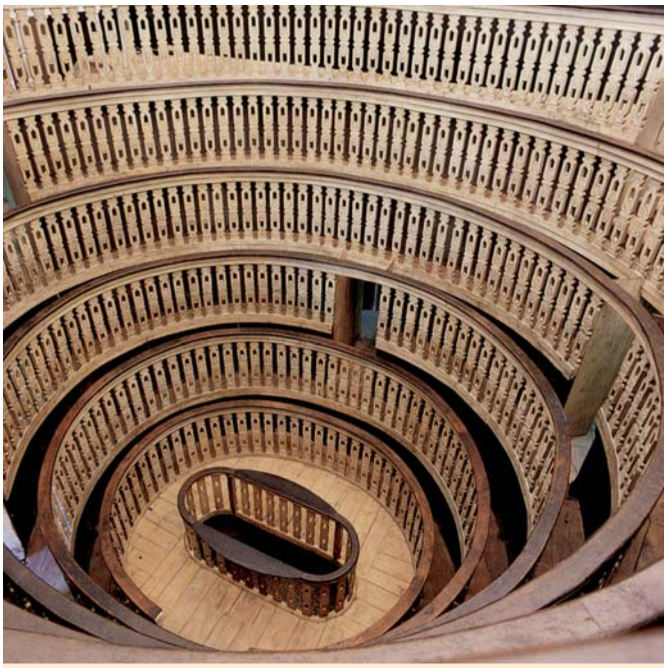
Professor Leopoldo Rubaltelli

Interview with the President of the Italian Society of Ultrasound in Medicine and Biology (SIUMB), Professor Leopoldo Rubaltelli (LR) February 2008. Interview by Michael Bachmann Nielsen (MBN).

- MBN: Thank you for accepting this interview. Could you start by telling me a little bit about yourself and your current position?
- LR: I am currently the President of the Italian Society of Ultrasound in Medicine and Biology. I am professor of radiology in Padova. My first field of interest is Ultrasound especially research and education.
- MBN: I must admit that I have never been to Padova, maybe you can tell us a little bit about the city.
- LR: Padova is close to Venice. It has the second oldest university in Europe. Famous professors have taught there, including Galileo Galilei, Morgagni, Falloppio. There are approximately 40,000 students at Padova University currently.
- MBN: I know that the Italian Ultrasound Society is very large, constitutes approximately 10% of all EFSUMB members
- LR: Yes, there are almost 2,000 members; it is a mix of many clinical fields of specialization. I would estimate that 20% are radiologists like me, but nearly all-medical branches are represented.
- MBN: I know you have an Italian Ultrasound journal that was recently changed to being entirely in the English language
- LR: Yes, we have had a journal in Italian and in 2007 it was changed entirely to English and titled Journal of Ultrasound. There are 4 issues each year. We accept review articles, original research, case reports and others.
- MBN: Do you have a newsletter or is that included in your journal

SIUMB Congress 2007

- LR: There is a news section within the journal of Ultrasound. This news section is in Italian.
- MBN: I know you have a very large annual meeting and also know that the EFSUMB Publications, Education and Professional standards committees are planning to meet during the congress. Could you tell us a little bit about your annual congress?
- LR: This year's annual meeting will be held in November in Rome. We expect 1,500 participants. The meeting is actually in 2 parts, there is the congress part itself where research is presented and there is another part with courses in Ultrasound.
- MBN: Speaking of courses. How do you run courses in Italy and do you have a certificate for practice in ultra-sound
- LR: I think there are about 20 schools certified for teaching basic ultrasound and about 25 schools for advanced ultrasound, the latter being e.g. vascular ultrasound, Doppler, interventional ultrasound, senology and many more. All these schools are approved by SIUMB - the Italian Society of Ultrasound in Medicine and Biology.
- MBN: We mentioned earlier the Journal of Ultrasound. The official journal of EFSUMB is Ultraschall in der Medizin/European Journal of Ultrasound; I know that several Italians have individual subscriptions. Do you think that at some time SIUMB will consider bulk subscription
- LR: My personal opinion is that Ultraschall in der Medizin/European Journal of Ultrasound is a very good journal and I hope that we in the future can consider a joint subscription.
- MBN: Thank you very much for taking your precious time to give this interview. Do you have any views upon the future of Ultrasound in Europe and in EFSUMB in particular
- LR: In particular I have appreciated the recent guidelines that have been published by EFSUMB. In my opinion they are examples of useful co-operation in the federation involving many member countries. I am sure this is something that EFSUMB is very proud of.



Anatomy Theatre Padua (1594)