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REPORTS

AMERICAN INSTITUTE OF ULTRASOUND IN MEDICINE

The Twenty-Eighty Annual Convention of the American Institute of Ultrasound in Medicine and the Twelfth Annual Convention of the Society of Diagnostic Medical Sonographers were concurrently held in New York City during October 18-21 1983. This combined four-day meeting was held at the New York Hilton with a total attendance of approximately 4500. The conference included categorical courses in OB/GYN, abdomen, basic science, pediatrics and cardiology; a symposium on current controversies in ultrasound; a plenary session on Doppler ultrasound; scientific sessions on instrumentation, bioeffects, OB/GYN, neurosonology, abdomen, cardiology, abdominal intervention, fetal cardiology, pediatrics, ophthalmology, veterinary ultrasound, and work-in-progress; meet-the-professor sessions; clinical case discussions; film reading panel; fireside chats on bioeffects and safety, breast imaging, cardiac ultrasound, legal aspects of ultrasound, education and salaries, and tissue characterization; and a five-session tissue characterization symposium. The basic science categorical course included the following presentations:

"Focusing and Resolution Principles of Line and Sector Arrays"
Albert Goldstein
"Sector Scanners - What Kind of Real-Time Scanner to Use"
Fred Winsberg
"Medical Ultrasonic Instrumentation - A State-of-the-Art Review".
James F. Havlice, John D. Larson
"Acoustic Imaging, The Inverse Scattering Approach -- Theory, Practical Limitations and Real Data Examples"
Jan Ridder, A.J. Berkhout, P.R. Mesdag
"A Review of Tissue Characterization from Ultrasonic Scattering"
Robert C. Waag.

Eighty-five exhibitors demonstrated the latest in diagnostic ultrasound equipment, accessories, and publications.

Scientific paper presentations totalled 187, up 73% over the previous convention. Official Proceedings are available from the A.I.U.M. office, 4405 East-West Highway, Suite 504, Bethesda, MD 20814. Summaries of the material presented in the Instrumentation and Bioeffects Sessions and Tissue Characterization Symposium follow.

INSTRUMENTATION

Two Instrumentation Sessions were presented, the first of which was primarily concerned with Doppler and signal processing techniques. S. Foster and W. O'Brien described a novel method for extracting blood flow profiles using time-domain correlation analysis. Computer simulation results and in-vitro experimental data were displayed, and good agreement between the two was demonstrated. K. Namekawa et al dealt with real-time two-dimensional imaging of blood flow within the heart. Pulsed Doppler information was used to color-encode the direction of blood flow; a real-time gray-scale B-mode image was displayed simultaneously with the color-coded blood flow information. A video recording demonstrated clear differences between normal blood flow in the heart and abnormal flow with swirling and flow reversal. K. Iimuma et al also described a technique for two-dimensional blood flow imaging. They have implemented a real-time moving target indicator technique using a phased array system. The system superimposes color-coded blood flow data on a static gray-scale B-mode image. S.K. Holland et al presented in-vitro experimental results of quantitative pulsed-Doppler blood-flow measurements in deep-seated vessels. Their analysis indicated that large errors can occur if the effects of frequency-dependent attenuation in tissue and the Rayleigh scattering characteristics of blood are not taken into account. S. Matsuo et al described a dual-system probe that consisted of a pulsed Doppler unit and a real-time linear-array scan head. The ability to view real-time B-mode images and obtain flow data was demonstrated, and design parameters and objectives were described. A digital detection scheme for resolution improvement in real time was described by I. Beretsky et al. The technique is based upom sampling rf waveforms at high rates relative to pixel dimensions and appropriately summing the digitized data. E.J. Farrell et al presented a method in which color coding is used to display three-dimensional data reconstructed from a series of two-dimensional ultrasound scans. Ultrasound echoes that fall into a particular amplitude range are represented as a certain color hue, such as red.

Spatial depth information is presented as an oblique projection of all scans, with brightness increasing from the back of the scanned object to its front. A paper by J.F. Brinkley described the use of artificial intelligence techniques to determine in-vivo organ shape and to obtain volume measurements from ultrasound data. The technique involves instructing the computer on which types of shapes to expect prior to analysis. The technique was demonstrated with data from balloon models. M.W. Vannier et al discussed their technique for three-dimensional surface image reconstruction from real-time B-mode scans. The technique was originally devised for use with CT scans. Images of an in-vitro dog brain and a surgical glove were displayed. S. Umemura and co-workers presented a paper on digital real-time dynamic-focus imaging system using a modified synthetic aperture scanner. High frame rates were achieved by using a phased quadrature sampling technique that can reduce the sampling frequency to one-third of the required rate for simultaneous sampling.

The remaining papers on instrumentation were present in a second session. T. Cohen-Overbeek et al discussed a non-invasive technique for assessing uteroplacental blood flow. A 2-MHz pulsed Doppler unit was used in conjunction with a 3.5 MHz linear array scanner. The authors defined two indices based on flow parameters and found that these were correlated with various fetal conditions. S. Smith et al detailed the fabrication and testing of a frequency-independent contrast-detail phantom. Phantoms containing 69-μm plastic scatterers of differing concentrations were used. Experimenta data obtained with transducers having different center frequencies agreed very well with theoretical predictions. J. Ridder and A.J. Berkhout described a synthetic focussing system for medical imaging. The time required for acquistion of 1 Mbyte of data was 100 ms. while image reconstruction required about 1 minute. The authors reported that the -6dB resolution of 0.4 mm was independent of depth over a 1- to 15-cm range. Although only wire phantom data were presented, clinical trials have recently been initiated. R.W. Barnes et al reported on the generation of high axial resolution excitation pulses for ultrasound transducers. A feedback control system approach is used which incorporates the transducer transfer function; the input voltage waveshape required to generate the desired output pressure pulse can be determined. The method was applied with a 1-MHz linear array and generated a pulse whose temporal main lobe provided resolution ordinarily obtained at 5-MHz.

BIOEFFECTS

The bioeffects session included nine regular scientific contributions and three works-in-progress presentations. The papers included several dealing with tests for effects on various systems, examination of mechanisms, and a report of the measured range of outputs of clinical diagnostic instruments.

Papers by Fred Lizzi's group at Riverside Research Institute showed that a model to predict temperature rise and extent of damage (lesion size) in thin tissue such as the chorio-retinal complex gives good agreement with experimental measurements of temperature and lesion size. They also reported that there was a synergism between ultrasound and radiation in the treatment of a subcutaneous human tumor implanted in a nude mouse, suggesting the possibility of reduced energy levels in clinical treatment. Another effect with potential beneficial clinical application was reported by Mortimer et al of the NRC of Canada. They showed evidence of increased aortic outflow in cats as a result of ultrasound irradiation of the heart at therapeutic levels. This effect was greatest at higher heart rates, and it was also shown that the ultrasound could eliminate pulsus alternans and therefore is being investigated for treating tachycardia. Two presentations were made by Sikov's group from Battelle concerning tests for biological effects. They reported that malformations occurred for the rat after exposure at day 9 of gestation to 0.8 MHz ultrasound for 5 min or more only when intensities were 2.35 W/cm^2 or greater and cautioned that this study related to diathermy and not diagnosis. They also looked for, but found no effect on maternal blood flow to the exteriorized placenta or on the amino acid transport system of the placenta when it was exposed to 1 W/cm^2 2MHz cw ultrasound for 30 and 60 minutes or 2.2 W/cm^2 SPTA pulsed ultrasound. Additionally, the three works-in-progress papers dealt with tests for effects and mechanisms. These included a report by Miller's group at Rochester of a lack of effect on human lymphocytes exposed in vitro to pulsed and cw ultrasound, even when cw exposures were sufficient to cause lysis of 10-15% of the cells. Two papers from Edmond's group at SRI reported a better correlation of effects on growth with ultrasonic intensity than with acoustic emissions, and the induction of protein synthesis by exposure to ultrasound, both in a Neuro 2-A cell line exposed in suspension to cw ultrasound. They were surprised by the first result which comes from preliminary studies and feel that the second result may indicate damage to the membrane, possibly the ($Na^+ - K^+$) ATP-ase pump which induces synthesis of repair proteins. Another paper given by Dr. Gross from Texas A & M University and colleagues D. Miller from Vermont and A. Williams from Manchester, U.K. reported that no bubbles were detected in arteries of dogs during exposure of the left ventricular outflow tract to cw ultrasound at up to 16 W/cm^2. However, for high intensity exposure of the heart there appeared to be a release of bubbles into the arteries when the sound was turned off. Dr. Stewart from NCDRH provided a summary of the output of intensities of diagnostic instruments, particularly fetal

imaging equipment, which were shown to span a large range. It was suggested as unlikely that the performance of these systems would vary as much, so that both output and performance should be considered at purchase. Another paper dealt with the computation and color graphic display of heating distributions in absorbing spheres and cylinders. Yet another showed that there is little evidence of refraction or phase aberration effects on the ultrasound beam in situ and that relatively simple corrections for attenuation give good agreement with experimental results.

TISSUE CHARACTERIZATION

A set of papers dealt in general with backscattered data and methods. R. Kuc demonstrated that the theoretical variance of the attenuation estimate is proportional to $(fd)^{-4}$ using an optimal estimator on rf data of bandwidth f gathered from a wedge of tissue of dimension $d^2 \times w$ where w is the width of the interrogating ultrasound beam. Accuracy limitations imposed by bandwidth and tissue shape on an attenuation estimator were discussed by C. Meyer. M. Fink presented a paper for F. Hottier et al which demonstrated that a narrowband analysis of short term Fourier periodograms (spectrograms) could be used to attain attenuation estimates independent of frequency dependent power loss assumptions. Experimental attenuation measurements included the demonstration by J. Ophir and P.A. Narayana showing that the attenuation coefficient of normal liver was proportional to frequency to the first power. Fatty livers demonstrated a power law dependence on frequency to the 1.2-1.4 power. The total attenuation coefficient was modeled as a linear combination of a first power and fourth power term. The ratio of coefficients of the nonlinear term to the linear term was approximately 1% for normal livers and 8-13% for fatty livers. K.J. Parker and R.C. Waag reported rf acquisition of backscatter in the image plane from a 10 cm^2 region of breast tissue obtained from an Octoson scanner. Signal processing included reconstruction of the original rf signal before TGC and amplifier compression effects. The attenuation coefficient was estimated by a least square error fit of an exponential function to the mean values of the backscattered pressure. The analysis was performed over the limited bandwidth of 1 MHz. An attenuation of $0.6\ f^{1.3}$ was reported. In vivo reports were presented by M. O'Donnell and H.F. Reilly presented clinical results from quantitative backscatter analyses on 25 human subjects in which 13 had normal liver, 6 had adenocarcinomas of the liver and 6 had cirrhotic liver. The mean backscatter coefficients for the three groups of normal, adenocarcinoma and cirrhosis was 3.5×10^{-4}, 8.3×10^{-4}, and 1.3×10^{-4}, $cm^{-1}\ ^{-1}$, respectively. The adenocarcinoma group and the cirrhotic group were statistically different from normal at the level $p \lesssim 0.01$. E.J. Feleppa, D.L. King et al presented clinical co-relations with signal processing results on rf liver data. The spectral amplitude, attenuation coefficient and its residual were correlated with normal and cirrhotic liver. J.A. Campbell and R.C. Waag presented experimental data on the differential and total scattering cross sections of calf liver. Normalized scattered power as a function of angle was found to be similar for all of the samples and nearly independent of frequency. The majority of the power was scattered in the forward direction. The ratio of power loss from the incident beam by scattering to that lost by absorption was estimated to be approximately 2% over the frequency ranges from 3-7 MHz. E.J. Feleppa, F. Lizzi et al presented signal processing techniques on rf data from the eye retina and postulated the ability to identify choroidal metastatic carcinomas normal choroid, and choroidal melanomas based on three parameters of slope, intercept and residual extracted in the signal processing. D.E. Robinson, G. Kossoff et al demonstrated a method of computing in vivo liver velocities by correcting for the refraction effects in two B mode images by two widely separated transducers. The degree of refraction was determined by crosscorrelation of the two images over a limited region of interest. The current method includes no compensation for body wall and demonstrates a $\pm$ 15 m/s reproducibility. L.L. Fellingham et al has modelled liver as a semi-regularly spaced array of point scatterers and presented a signal processing technique of averaging the first peak of the autocorrelation function to determine the spacing. Normal liver was found to have a spacing of 1.1 mm while liver affect by Hodgkins disease had a mean spacing of $1.6 \pm .36$ mm. D.K. Nassiri, C.R. Hill et al presented the results of texture analysis on B-mode images of abdominal tumors. Changes in the second angular moment as well as the power spectra were demonstrated for patients undergoing radiotherapy. T.O. Wilcox, T.C. Pilkington and O.T. von Ramm demonstrated the ability to separate tissue of normal and infarcted myocardium based on the difference in variances and difference in means obtained from the affected regions of interest in the 2-D images. Toward the goal of detecting thrombus by 2D echocardiography, K.K. Shung et al presented experimental evidence that velocity in blood increased 2% as the blood was allowed to clot over a 24 hour period. The attenuation coefficient increased by 24% and backscattering increased by 18 dB in the same 24 hour period.

Other potential tissue characterization techniques were presented. P.A. Lewin and L. Bjorno were able to generate and measure shear wave velocities in pig liver of 100 m/s. F. Dunn, W.K. Law and L.A. Frizzell presented results that suggest that the degree of nonlinearity in wave propagation depends linearly upon the dry weight concentration of protein in aqueous solutions as well as the architectural features of whole tissues.

M.S. Roos and R.E. Apfel demonstrated the ability to compute the compressibility and density of single red blood cells from 90^{o} and 135^{o} scattering. I. Amir and V.L. Newhouse used sharply focused fields to generate a coherent echo from a random medium which allowed the separation of density and cross section of scatterers. F.E. Barber demonstrated a method for detecting the directivity of scattering from tissues which may be another useful parameter in tissue characterization. J.W. Hunt, S.H.P. Bly et al examined the effects of multiple scattering in test phantoms. The results lead them to conclude that multiple backscattering in livers is negligible while the effect may be significant in breast imaging. Thus the contrast between breast carcinoma and cystic lesions may be seriously degraded. R.F. Wagner et al demonstrated differences in the autocorrelation function computed from texture in B-mode images for both deterministic and random media. T.R. Mesdag and A.J. Berkhout demonstrated the use of k-space for tissue characterization from backscattered data. Autocorrelation of B-mode images were also described.

Several papers were dedicated to the inverse problem associated with through transmission tomographic imaging. J.F. Greenleaf presented a method which makes use of the discrete Rytov transformation (as opposed to approximation) which allows a computed solution to the exact wave propagation problem. This approach leads to the Riccati wave equation. One major problem to be overcome is the phase unwrapping of the detected wavefront. A.J. Devaney presented his method of filtered backpropagation as opposed to backprojection. On simple phantoms he demonstrated how the solution rapidly converged after only 7 backpropagation angles were used. T.L. Chenevert, P.L. Carson et al demonstrated improved speed of sound reconstructions using correlation detection at the receiving transducer for determining the time-of-flight. Significantly improved spatial resolution in the speed of sound images was demonstrated for both phantoms and clinical breast scans. J.F. Whiting et al showed computed tomographic speed of sound images made using linear arrays mounted as an attachment on the Ausonics breast scanning system. Now that a rapid computed tomographic scanning system has been developed, clinical trials elsewhere are planned to use the computed tomography speed of sound system to first screen the breast for suspicious regions and then to use the conventional pulse echo system for differential diagnosis.

A tissue characterization symposium is being planned for the next AIUM meeting in Kansas City, September 16-19, 1984. Contributed papers will be selected for a one-day symposium, probably on Sunday, September 16.

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ACOUSTICAL IMAGING CONFERENCE

From October 26 to October 28 1983 the Thirteenth Acoustical Imaging Conference was held at the Holiday Inn in Minneapolis, Minnesota, hosted by the University of Minnesota, the Office of Naval Research and co-chaired by Drs. Mustafa Kaveh, Rolf Mueller and James F. Greenleaf.

John Wild of Minneapolis gave a special lecture outlining the history of medical ultrasonics beginning with his first experiments in 1950 and outlining various biological results in which backscatter measurements were made in different tissues. Evidence for the capabilities of ultrasonic detection of cancer was found by his experiments in the early 50s.

Several talks on inversion tomography were given, including a talk on the relationship between the Born and Rytov approximations by Sidney Leeman of Queen Elizabeth College and a new technique for the Fourier Transform method of inverse scattering by Gregory Beylkin of Schlumberger-Doll Research. Mehrdad Soumekh of Worcester Polytech., described a technique for Fourier domain reconstruction methods and a new interpolation method for interpolating from the polar coordinates of diffraction tomography reconstruction to the cartesian coordinates of the fast Fourier transform. Reconstructions at multiple frequencies using diffraction tomography were demonstrated by the group from Mayo Clinic. Peder Pedersen from Drexel described the effects of acoustic noise and limited transducer bandwidth on inverse scattering and impedance measurments. Several acoustic microscopy papers were given, including one on acoustic imaging of complex geometries by Michael Oravecz from Sonoscan, Inc., and a technique for computer-assisted tomography using microscopy by Zse-Cherng Lin, University of California. In addition, effects of anisotropy on contrast and the scanning acoustic microscope was described by Michael Somekh of Oxford University.