information on other species. We address both impulsive and continuous sounds from sources including impact pile driving, blasting, heavy equipment noise, and sonar. Interim thresholds for expecting injurious effects from some of these sources are in use, and refinements to our analysis of forest-management activities were recently applied to landscape-scale consultations. The bioacoustic research needs of this unique species continue to emerge as we apply these approaches in both the aquatic and terrestrial environments where murrelets occur.

4:40

4pABb11. The American National Standards Institute/Acoustical Society of America new (draft as 5 May 2012) standard method to define and measure the background sound in quiet areas. Paul Schomer (Schomer and Associates Inc., 2117 Robert Drive, Champaign, IL 61821, schomer@SchomerAndAssociates.com) and Kurt Fristrup (Natural Sounds and Night Skies Division, National Park Service, Ft. Collins, CO)

This draft standard is a joint work effort of S3/SC1, the animal bioacoustics committee, and S12, the noise committee. The draft standard includes 3 major, distinct components: (1) a method to measure the background using unattended instruments, and based on L-levels with L-90 as the default; (2) a definition for ANS-weighted sound pressure level, which is simply the A-weighted sound level after deleting all of the sound energy in the 2-kHz octave band or above; and (3), requirements for monitoring the sound in parks and wilderness area. The background measurement procedure is mainly for low-noise residential areas and relevant to the siting of such installations as wind farms and power plants. The ANS-weighting is applicable to both measurement of background and monitoring in parks. The requirements for monitoring in parks and wilderness areas ensure that measurements adequately capture the range of natural ambient conditions. The draft standard provides for two grades of measurement/monitoring: engineering or survey. In addition, this is the first standard to clearly and unambiguously define and establish the requirements for the measurement of percentile levels (exceedance values).

5:00–5:50 Panel Discussion

THURSDAY AFTERNOON, 25 OCTOBER 2012 TRIANON B, 2:00 P.M. TO 4:00 P.M.

Session 4pBA

Biomedical Acoustics: Therapeutic and Diagnostic Ultrasound

Robert McGough, Chair
Department of Electrical and Computer Engineering, Michigan State University, East Lansing, MI 48824

Contributed Papers

2:00

4pBA1. Effect of skull anatomy on intracranial acoustic fields for ultrasound-enhanced thrombolysis. Joseph J. Korfhagen (Neuroscience Graduate Program, University of Cincinnati, 231 Albert Sabin Way CVC 3948, Cincinnati, OH 45267-0586, joekorf3@gmail.com), Jason L. Raymond (Biomedical Engineering Program, College of Engineering and Applied Science, University of Cincinnati, Cincinnati, OH), Christy K. Holland (Internal Medicine, Division of Cardiovascular Diseases, University of Cincinnati, Cincinnati, OH), and George J. Shaw (Emergency Medicine, University of Cincinnati, Cincinnati, OH)

Transcranial ultrasound improves thrombolytic drug efficacy in ischemic stroke therapy. The goal of this study was to determine the ideal ultrasound parameters for obtaining peak rarefactional pressures exceeding the stable cavitation threshold at the left anterior clinoid process (lACP) of the skull. This location is near the origin of the middle cerebral artery, a common site for ischemic stroke. For 0.5, 1.1 and 2.0-MHz ultrasound transducers, pulse repetition frequencies (PRF) ranging from 5.4-8.0 kHz were studied at a 50% duty cycle. Attenuation and ultrasound beam distortion were measured from a cadaveric human skull. Each transducer was placed near the left temporal bone such that the unaberrated maximum acoustic pressure would be located at the lACP. A hydrophone measured the acoustic field around the lACP. Free-field measurements were taken in the same locations to determine attenuation and beam focus distortion. For 5 skulls, the average pressure attenuation at the lACP was 68 ± 19, 91 ± 5.1, and 94 ± 4.7% for 0.5, 1.1, and 2.0 MHz, respectively. The degree of displacement of the beam focus depended on the skull properties, but not the center frequency nor PRF. In conclusion, lower frequencies exhibited lower attenuation and improved penetration at the lACP. This work was supported by NIH-3P50-NS044283-06S1.

2:15

4pBA2. Fiber-optic probe hydrophone measurement of lithotripter shock waves under *in vitro* conditions that mimic the environment of the renal collecting system. Guangyan Li, James McAteer, James Williams (Department of Anatomy and Cell Biology, Indiana University School of Medicine, 635 Barnhill Dr., Indinapolis, IN 46202, gyli@iupui.edu), and Michael Bailey (Applied Physics Lab, University of Washington, Seattle, WA)

The fiber-optic probe hydrophone (FOPH) is the accepted standard for characterization of lithotripter shock waves, and measurements are typically conducted in water in the unconstrained free-field. To sort out potential factors that may affect *in vivo* measurements within the collecting system of the kidney, we assessed for the effect of contact between the fiber tip and tissue as might occur when working "blind" within the urinary tract, and contamination of the fluid medium (isotonic saline) by blood as often occurs during endourological procedures. Studies were performed using a Dornier Compact-S electromagnetic lithotripter. Contact of the optical fiber with *ex vivo* kidney tissue lowered pressure readings. The effect was greatest (~45% reduction) when the fiber was oriented normal to tissue, but pressures were also reduced when a length of fiber rested parallel against tissue (~5-10% reduction). Placing the fiber tip near, but not touching tissue, increased variability in peak negative pressure (P^-). Adding porcine blood to the medium (up to 10% V/V) had no effect on readings. These findings suggest that position/orientation of the FOPH relative to surrounding tissue is critical and

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must be controlled, but that micro-hematuria will not be a confounding factor for *in vivo* measurements. (NIH-DK43881)

2:30

4pBA3. Speckle generation and analysis of speckle tracking performance in a multi-scatter pressure field. Ayse Kalkan-Savoy (Biomedical Engineering, UMass-Lowell, 1 University Ave, Lowell, MA 01854, ayse.k.savoy@gmail.com) and Charles Thompson (Electrical and Computer Engineering, UMass-Lowell, Lowell, MA)

Speckle tracking imaging is used as a method to estimate heart strain. An analysis of accuracy of speckle tracking and its potential to be utilized in quantification of myocardial stress through estimation of heart motion is examined. Multiple scattering effects are modeled using the Kirchoff integral formulation for the pressure field. The method of Pade approximants is used to accelerate convergence and to obtain temporal varying characteristics of the scattered field. Phantoms having varied acoustical contrast media and speckle density are used in this study. The effectiveness of inter-image frame of correlation methods for estimating speckle motion in high contrast media is considered. (NSF Grant 0841392)

2:45

4pBA4. Analytical and numerical approximations for the lossy on-axis impulse response of a circular piston. Robert McGough (Department of Electrical and Computer Engineering, Michigan State University, 2120 Engineering Building, East Lansing, MI 48824, mcgough@egr.msu.edu)

In biological tissues, the frequency dependence of attenuation and speed of sound for ultrasound propagation is described by the power law wave equation, which is a partial differential equation with fractional time derivatives. As demonstrated previously, the time domain Green's function for the power law wave equation combined with the Rayleigh-Sommerfeld integral is an effective reference for calculations of the lossy on-axis impulse response of a circular piston. Using the result obtained from this reference, two different approximations to the lossy on-axis impulse response are evaluated. The first approximation is an analytical expression that is proportional to the difference between two cumulative distribution functions for maximally skewed stable probability densities. The second approximation numerically convolves the lossless impulse response with a maximally skewed stable probability density function. The results show that both approximations achieve relatively small errors. Furthermore, the analytical approximation provides an excellent estimate for the arrival time of the lossy impulse response, whereas the departure time of the lossy impulse response is more difficult to characterize due to the heavy tail of the maximally skewed stable probability density function. Both approximations are rapidly calculated with the STABLE toolbox. [supported in part by NIH Grant R01 EB012079.]

3:00

4pBA5. The lossy farfield pressure impulse response for a rectangular piston. Robert McGough (Department of Electrical and Computer Engineering, Michigan State University, 2120 Engineering Building, East Lansing, MI 48824, mcgough@egr.msu.edu)

The impulse response of the velocity potential is useful for computing transient pressures in lossless media, especially for calculations in the nearfield region. Closed form expressions for the lossless impulse response of the velocity potential in the nearfield are available for circular and rectangular transducers and for several other geometries. A closed form lossless farfield expression is also available for rectangular transducers. Typically, when the effects of attenuation are introduced, the numerical calculation is performed in the frequency domain, and the time response is obtained with an inverse fast Fourier transform. To derive an equivalent analytical result directly in the time domain, all path lengths that appear in the denominator scaling term of the lossy diffraction integral are treated as constants, and a binomial expansion is applied to the path length that appears in the time delay term. The resulting analytical expression, which describes the lossy farfield pressure impulse response, is directly expressed in terms of maximally skewed stable probability density functions and cumulative distribution functions. Results are compared with the Rayleigh Sommerfeld integral, and excellent agreement is achieved in the farfield region. [supported in part by NIH Grant R01 EB012079.]

3:15

4pBA6. Histological analysis of biological tissues using high-frequency ultrasound. Kristina M. Sorensen (Department of Mathematics and Statistics, Utah State University, 698 E 700 N, Logan, UT 84321, Kristina.Sorensen@aggiemail.usu.edu), Timothy E. Doyle, Brett D. Borget, Monica Cervantes, J. A. Chappell, Bradley J. Curtis, Matthew A. Grover, Joseph E. Roring, Janeese E. Stiles, and Laurel A. Thompson (Department of Physics, Utah Valley University, Orem, UT)

High-frequency (20-80 MHz) ultrasonic measurements have the potential to detect cancer and other pathologies within breast tissues in real time, and thus may assist surgeons in obtaining negative or cancer free margins during lumpectomy. To study this approach, ultrasonic tests were performed on 34 lumpectomy margins and other breast tissue specimens from 17 patients to provide pulse-echo and through-transmission waveforms. Time-domain waveform analysis yielded ultrasonic attenuation, while fast Fourier transforms of the waveforms produced first- and second-order ultrasonic spectra. A multivariate analysis of the parameters derived from these data permitted differentiation of normal, adipose, benign, and malignant breast pathologies. The results provide a strong correlation between tissue microstructure and ultrasonic parameters relative to the morphology and stiffness of microscopic features such as ductules, lobules, and fibrous structures. Ultrasonic testing of bovine heart, liver, and kidney tissues supports this correlation, showing that tissues having stiff fiber-like or filled-duct structures, such as myocardium or ductal carcinomas, display greater peak densities in the ultrasonic spectra than tissues with soft, open duct-like structures, such as kidney tissue or normal breast glands. The sensitivity of high-frequency ultrasound to histopathology may assist in eliminating invasive re-excision for lumpectomy patients. [Work supported by NIH R21CA131798.]

3:30

4pBA7. The design and fabrication of a linear array for three-dimensional intravascular ultrasound. Erwin J. Alles, Gerrit J. van Dijk (Laboratory of Acoustical Wavefield Imaging, Delft University of Technology, Delft, Zuid-Holland, Netherlands), Antonius van der Steen (Biomedical Engineering, Thorax Centrum, Erasmus MC, Rotterdam, Zuid-Holland, Netherlands), Andries Gisolf, and Koen van Dongen (Laboratory of Acoustical Wavefield Imaging, Delft University of Technology, Lorentzweg 1, Room D212, Delft, Zuid-Holland, Netherlands K.W.A., vanDongen@TUDelft.nl)

Current intravascular ultrasound catheters generate high resolution cross-sectional images of arterial walls. However, the elevational resolution, in the direction of the catheter, is limited, introducing image distortion. To overcome this limitation, we designed and fabricated a linear array which can be rotated to image a three-dimensional volume at each pullback position. The array consists of eight rectangular piezo-electric elements of 350 μm by 100 μm operating at a center frequency of 21 MHz with a fractional bandwidth of 80 %, separated by a kerf of 100 μm. The array has been tested on both an ex vivo bovine artery and phantoms and, using the real aperture of the array, axially densely sampled images of the artery are obtained in every position. The array consistently yields significantly higher resolution in longitudinal images and more detail in radial images compared to a conventional catheter.

3:45

4pBA8. Parametric imaging of three-dimensional engineered tissue constructs using high-frequency ultrasound. Karla P. Mercado (Department of Biomedical Engineering, University of Rochester, Rochester, NY 14627, karlapatricia.mercado@gmail.com), María Helguera (Center for Imaging Sciences, Rochester Institute of Technology, Rochester, NY), Denise C. Hocking (Department of Pharmacology and Physiology, University of Rochester, Rochester, NY), and Diane Dalecki (Department of Biomedical Engineering, University of Rochester, Rochester, NY)

The goal of this study was to use high-frequency ultrasound to nondestructively characterize three-dimensional engineered tissues. We hypothesized that backscatter spectral parameters, such as the integrated backscatter coefficient (IBC), can be used to quantify differences in cell concentration in engineered tissues. We chose the IBC parameter since it estimates the backscattering efficiency of scatterers per unit volume. In this study, acoustic fields were generated using single-element, focused transducers (center frequencies of 30 and 40 MHz) operating over a frequency range of 13 to 47