1205 Ultrasound Tissue Characterization

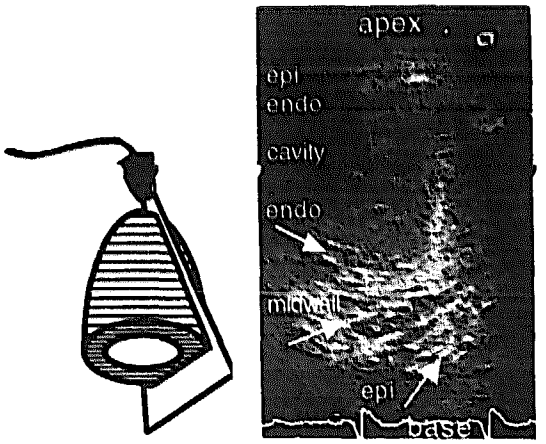
Wednesday, April 1, 1998, Noon–2:00 p.m.
Georgia World Congress Center, West Exhibit Hall Level
Presentation Hour: Noon–1:00 p.m.

1205-137 Determination of Myocardial Fiber Architecture In Man by High-Resolution Echocardiography

P.R. Hunziker, N. Liel-Cohen, M. Scherrer-Crosbie, T. Buck, R.A. Levine, M.H. Picard. *Massachusetts General Hospital, Boston, USA*

The spatial orientation of myocardial fibers is a fundamental architectural feature of the heart that is of major importance in myocardial mechanics and may influence ventricular remodeling in heart disease. However, myocardial fiber orientation is difficult to study in vivo. Therefore, we studied the feasibility of determining myocardial fiber orientation in man by echocardiography using high frequency probes.

Methods: In 13 human normal volunteers (age 7–50 years), high frequency trans-thoracic echocardiographic image loops were acquired (7 MHz transducer, Acuson Sequoia). From an apical window, the imaging plane was directed so as to slice the left ventricular walls in tangential fashion (fig). From digitized loops, the fiber orientation angle relative to the equatorial plane was determined for the different layers of the LV wall.



Results: Fiber orientation could be assessed in all volunteers in septum and inferior wall, in 85% of pts in the lateral and in 23% in the anterior wall and could clearly be differentiated from lateral resolution artifacts. Myocardial fiber orientation (arrows) formed a left-handed helix in the inner layers, were equatorial in the midwall and right-handed helical in the outer layers, in agreement to the results from autopsy studies. The observed fiber angle relative to the equatorial plane ranged from −30° near the endocardium to +60° near the epicardium.

Conclusion: This is the first study reporting determination of myocardial fiber architecture by echocardiography in man.

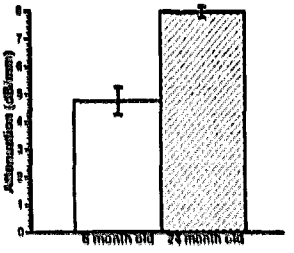
This new tool allows the investigation of an important structural feature of myocardial anatomy not readily accessible until now.

1205-138 Sensitive Detection of the Effects of Aging in Senescent Rat Myocardium With Ultrasonic *Tissue Characterization*

C.T. Nguyen, C.S. Hall, M.J. Scott, J.G. Miller, S.A. Wickline. *Barnes-Jewish Hospital, Washington University School of Medicine, St. Louis, Missouri, USA*

The aging process is accompanied by cardiac diastolic dysfunction related to increased tissue stiffness. Increased cross-linking of extra cellular matrix of the myocardium (e.g., collagen) has been suggested as a source of the change in tissue material properties with age, but no noninvasive diagnostic technique has yet been reported to delineate this condition. Accordingly, non-destructive quantitative ultrasound methods were used to define age-related changes in microscopic material properties of myocardium in senescent rats (24 months) as compared with younger control rats (6 months). The hearts of Fischer 344 rats were excised, then perfused and fixed in 10% buffered formalin. The lateral wall of the left ventricle was dissected out and then insonified with a high-frequency, high-resolution acoustic microscope in the pulse-echo mode. Frequency dependent attenuation coefficients were measured from 30 MHz to 42 MHz.

Result: The frequency averaged attenuation coefficient demonstrated an increase of 3.2 dB/mm for the 24 month group as compared with the 6 month group ($p < 0.01$) (see graph). The normalized heart weight showed no statistical difference between the two age groups (0.374 versus 0.375 mg/100gm body weight in 6 month and 24 month rats, respectively, p = N.S.).



Conclusion: The measured increase in ultrasonic attenuation coefficient for aged myocardium signified altered viscoelastic properties of the myocardial tissue at the cellular level that was specific for age rather than heart mass. We speculate that effects of aging on the extracellular matrix may be responsible for these changes in passive elastic behavior.

1205-139 Ultrasonic Tissue Characterization of Myocardial Collagen Crosslinking due to Non-enzymatic Protein Glycosylation

M. Janif, C.S. Hall, S.M. Handley, J.G. Miller, S.A. Wickline. *Barnes-Jewish Hospital at Washington University School of Medicine, St. Louis, MO, USA*

Background: Advanced Glycosylation End-products (AGE's) of myocardial *collagen in diabetic cardiomyopathy may be responsible for increased stiff*ness of the myocardium, decreased chamber compliance and diastolic dysfunction. Previous studies have shown that the long term effects of collagen crosslinking of diabetes can be modeled by incubating tissue in simple sugars. We now report the first use of ultrasonic tissue characterization methods to quantify matrix crosslinking in this condition. Incubation of tissue in maltose was employed to enhance collagen crosslinking and mimic the diabetic state.

Methods: The hearts of five Sprague-Dawley rats were sectioned into two transverse 4 mm slices. One slice was placed in normal saline and the second in 0.2 M maltose at room temperature under sterile conditions. After 10 days the tissue was removed for measurement of the ultrasonic attenuation coefficient with a 50 MHz acoustic microscope. The attenuation coefficient was determined by computing signal loss from the backscattered signal at multiple contiguous depths into the tissue from epi- to endocardium. The extent of the crosslinking was investigated by staining sections of the tissues for collagen.

Results: Frequency dependent attenuation coefficient was averaged over the frequency range from 30 to 50 MHz to determine an average value for attenuation. The average attenuation for the glycosylated tissue was 228 ± 14 dB/cm and for the non-glycosylated tissue was 149 ± 24 dB/cm ($p = 0.02$, t-test). Trichrome staining indicated superior preservation of cytoarchitecture in maltose soaked as compared to saline soaked tissue samples.

Conclusion: High frequency ultrasonic tissue characterization can define changes in tissue material properties that result from AGE's. Thus, potentially early detection of diabetic cardiomyopathy may be possible in susceptible individuals before onset of clinical signs and symptoms.

1205-140 Ultrasonic Tissue Characterization Identifies Altered Physical Properties of the Myocardium in a Rat Model of Insulin Resistance

A. Kovacs, M. Courtois, V.G. Davila-Roman, P.A. Ludbrook, J.E. Perez. *Washington University, St. Louis, MO, USA*

Background: Type I diabetes mellitus (DM) has been shown to be associated with abnormal ultrasonic scattering properties of the myocardium. To characterize the physical properties of the heart in type II DM, ultrasonic tissue characterization was performed in a rat model of insulin resistance.

Methods: Zucker fatty rats and their lean litter mates as controls were used in this study. Serial 2-D, M-mode and Doppler echocardiograms combined with measurements of the cyclic variation of integrated backscatter (CVIB) were performed in vivo. Hemodynamic measurements were obtained at the end of the study by closed-chest retrograde LV micromanometer catheterization.

Results: Compared to controls (n = 6), Zucker fatty rats (n = 6) developed concentric LVH (LV mass 0.52 ± 0.03 vs 0.74 ± 0.05 g, $p < 0.01$; relative wall thickness 0.12 ± 0.02 vs 0.15 ± 0.02, $p = 0.016$) beginning at 4 months