

2:15 p.m.

844-2

### Subendocardial Radial Strain Activation Imaging: A New Method to Quantify Regional Dyssynchrony in a Model of Left Bundle Branch Block and Biventricular Pacing

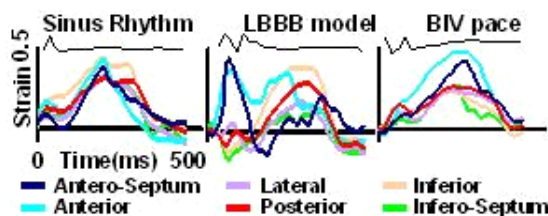
Kaoru Dohi, Micheal Pinsky, Hideaki Kanzaki, Donald Severyn, John Gorcsan, III, University of Pittsburgh, Pittsburgh, PA

**Background:** Quantification of left ventricular (LV) dyssynchrony has become clinically important for biventricular (BIV) pacing. Our objective was to test the hypothesis that the novel angle-corrected subendocardial strain imaging can quantify dyssynchrony in a left bundle branch block (LBBB) model and during BIV pacing.

**Methods:** Six open-chest dogs had echo images (Aplo 80, Toshiba Corp) from the mid-LV short axis that were analyzed by custom software for angle-corrected color-coded subendocardial strain in 6 radial sites. High fidelity LV pressure catheters measured dp/dt. Data were collected at baseline, LBBB simulated by right ventricular epicardial pacing, and BIV pacing.

**Results:** Normal regional time to peak subendocardial strain was  $236 \pm 30$  ms from the onset of the QRS complex. LBBB simulation resulted in dyssynchrony characterized by early activation of the antero-septum ( $99 \pm 40$  ms\*), and delayed free wall activation ( $340 \pm 46$  ms\*) associated with decreased LV dp/dt ( $-19 \pm 10\%$ ), \* $p < 0.05$  vs. normal. Dyssynchrony, defined as the difference between earliest to latest peak strain, was  $241 \pm 30$  ms in the LBBB model ( $p < 0.05$  vs. normal) and was significantly improved by BIV pacing to  $59 \pm 32$  ms ( $p < 0.0005$  vs. LBBB model). BIV pacing was associated with increased LV dp/dt ( $16 \pm 16\%$ ,  $p < 0.05$  vs. LBBB model).

**Conclusion:** Angle-corrected subendocardial radial strain activation quantified regional mechanical dyssynchrony and effects of BIV pacing in a model of LBBB and has promise for clinical application.



2:30 p.m.

844-3

### Preserved Radial Strain Explains Normal Ejection Fraction in Cardiac Amyloidosis Patients With Abnormal Longitudinal Strain

Karen M. Modesto, Angela Dispenzieri, Sanderson Cauduro, Marek Belohlavek, Bijoy Khandheria, Martha Lacy, Robert Kyle, Philip Greipp, Jamil Tajik, Morie Gertz, Theodore Abraham, Mayo Clinic, Rochester, MN

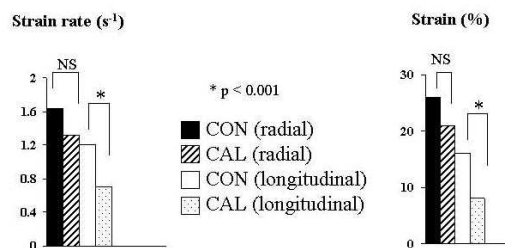
**Background:** Recent studies have shown reduced longitudinal strain in amyloidosis patients with cardiac involvement (CAL) and normal ejection fraction (EF). We sought to evaluate whether unchanged or compensatory increase in radial strain is the basis for the normal EF in these patients.

**Methods:** Conventional (ECHO) and tissue Doppler strain (SE) echocardiography was performed in 40 consecutive CAL patients and 10 age matched healthy volunteers (CON). Patients with hypertension, coronary artery disease and diabetes were excluded. Standard clinical views were used for ECHO. Parasternal short axis (mid ventricular), and apical 4 and 2 chamber, and long axis views were used for SE. Segmental longitudinal (all segments) and radial (mid anterior and inferior segments) systolic strain rate and strain were calculated.

**Results:** All subjects had normal wall motion and EF by ECHO ( $EF > 55\%$ , Simpson's and M-mode). Mean age ( $61.3 \pm 6.5$  CON vs  $61.4 \pm 10.4$  CAL,  $p = 0.96$ ) and proportion of males were similar between the two groups. Longitudinal strain and strain rate were significantly lower in CAL versus CON. In contrast, radial strain and strain rate were similar in both groups (Figure).

**Conclusion:** CAL is associated with preserved radial and reduced longitudinal strain

(and strain rate), despite normal EF by ECHO. In CAL, calculated EF, which reflects radial myocardial thickening, is normal probably due to preserved radial strain. There was no evidence of compensatory increase in radial strain/strain rate.



2:45 p.m.

844-4

### Tissue Doppler Strain Echocardiography Accurately Predicts Right Ventricular Systolic Function

Stig Urheim, Sanderson Cauduro, Robert Frantz, Michael McGoon, Marek Belohlavek, James Seward, Theodore P. Abraham, Mayo Clinic, Rochester, MN

**Background:** Assessment of RV function is critical to patient care in pulmonary hypertension. However, there is a paucity of non-invasive techniques capable of assessing RV function. We evaluated the ability of conventional (ECHO) and tissue Doppler strain echocardiography (TDSE) to predict RV systolic function. **Methods:** Simultaneous ECHO and TDSE were performed in consecutive patients ( $n=50$ , 32 with pulmonary hypertension) undergoing right heart catheterization. RV stroke volume, determined by thermodilution method, was used as the gold standard of RV systolic function, except in patients with significant tricuspid regurgitation (TR) when the Fick method was used. Vena contracta width was used to grade TR. Standard imaging protocols were used for ECHO and TDSE. We excluded patients with left ventricular ejection fraction  $< 0.55$ , valvular heart disease (except TR), cardiac surgery, coronary artery disease and hypertension. Univariate and multivariate regression analysis was used to test correlation between ECHO/TDSE and RV stroke volume. **Results:** TDSE parameters correlated more closely with RV stroke volume compared to ECHO (Table). Correlation improved after adjustment for TR. Systolic tissue displacement and RV systolic strain appeared to most closely reflect RV stroke volume. **Conclusion:** TDSE estimation of RV function is feasible and appears to provide accurate, non invasive assessment of RV function.

	Systolic tissue velocity	Tissue displacement	Systolic strain rate	Systolic strain	Isovolumetric acceleration	Acceleration time	RV index of myocardial performance
r value	0.35	<b>0.63</b>	0.22	<b>0.48</b>	0.28	0.3	0.05
p value	0.02	<b>&lt;0.0001</b>	0.15	<b>0.002</b>	0.1	0.06	0.7
r (adjusted for TR)	0.56	<b>0.74</b>	0.51	<b>0.60</b>	0.57	0.54	0.49
p value (after adjustment for TR)	0.003	<b>&lt;0.0001</b>	0.009	<b>0.01</b>	0.004	0.08	0.4

3:00 p.m.

844-5

### Assessment of Aortic Wall Mechanics in Marfan Syndrome by Transesophageal Echocardiography and Tissue Doppler Imaging

Antonio Vitarelli, Ysabel Conde, Ilaria D'Angeli, Ester Cimino, Simona D'Orazio, Simona Stellato, Viviana Padella, La Sapienza University, Rome, Italy

**Background:** The aim of our study was to investigate the potential value of transesophageal echocardiography combined with tissue Doppler imaging for the assessment of elastic properties of the thoracic aorta in patients with Marfan disease.

**Methods:** Twentyone patients (pts) with Marfan syndrome (Gent criteria) aged 13 to 52 years and sixteen normal controls were studied with multiplane transesophageal echocardiography (TEE). 7/21 pts had surgery for aortic dissection. The ascending and descending aorta were visualized in a TEE short axis view. Standard formulas and tissue Doppler imaging (TDI, Toshiba corp.) during TEE were used for the quantification of aortic elastic properties. Acceleration time (AT, msec), maximum wall expansion velocity ( $V_{max}$ , cm/sec), wall contraction E and A velocities (cm/sec), and peak systolic wall strain ( $\epsilon$ , %) were determined from TDI tracing.

**Results:** Ascending and descending thoracic aorta dilation ( $> 40$ mm and  $> 30$ mm) was present in 11/21 and 12/21 pts, respectively. Marfan patients had a lower distensibility and a higher stiffness index both in patients with dilated ( $p < 0.001$ ) and normal aortas ( $p < 0.05$ ). Highly significant differences were obtained between both groups for  $V_{max}$  ( $2.8 \pm 1.6$  vs  $6.7 \pm 1.8$  cm/sec,  $p < 0.001$ ), AT ( $68 \pm 7$  vs  $89 \pm 5$ ,  $p < 0.001$ ) and  $\epsilon$  ( $7.6 \pm 1.3\%$  vs  $24 \pm 2.9\%$ ,  $p < 0.001$ ). The indices derived from TDI were significantly decreased compared to controls both in patients with dilated ( $p < 0.001$ ) and normal aortas ( $p < 0.001$ ). Significant and independent predictors of aortic dilatation were systolic blood pressure ( $F = 19.2$ ,  $p < 0.005$ ), aortic stiffness index ( $F = 21.3$ ,  $p < 0.005$ ),  $V_{max}$  ( $F = 31.2$ ,  $p < 0.005$ ), and  $\epsilon$

( $F=33.6$ ,  $p<.005$ ). Decreased aortic strain,  $V_{max}$  and stiffness index were predictive of aortic dissection (Odds ratio = 3.9,  $p<.0001$ , 3.5,  $p<.0001$ , and 1.5,  $p<.005$ , respectively).

**Conclusions.** Our results show that in Marfan syndrome elastic properties of the thoracic aorta are significantly different from normal controls, even in the absence of vessel dilatation. TDI assessment of aortic wall mechanics in Marfan patients is more accurate than standard M-mode measurements and is predictive of aortic dilatation and dissection.

3:15 p.m.

844-6

#### Tissue Doppler-Derived Indices Correlate With Exercise Capacity in Patients With Apical Hypertrophic Cardiomyopathy

Jong-Won Ha, Namsik Chung, Jeong-Ah Ahn, Seok-Min Kang, Se-Joong Rim, Yangsoo Jang, Won-Heum Shim, Seung-Yun Cho, Yonsei University College of Medicine, Seoul, South Korea

**BACKGROUND:** Apical hypertrophic cardiomyopathy (ApHCM) is a unique form of HCM, in which the hypertrophy of myocardium predominantly involves the apex of the left ventricle (LV). Although impaired LV diastolic function is a prominent feature of hypertrophic cardiomyopathy, diastolic function and its relation to exercise capacity in ApHCM is not clearly defined. Diastolic mitral annular velocity ( $E'$ ) measured using Doppler tissue imaging (DTI) has been reported to be a preload independent index of myocardial relaxation and LV filling pressures can be estimated by combining mitral inflow ( $E$ ) and  $E'$ . The purpose of this study was to determine the relationship between diastolic annular velocities combined with conventional Doppler indices and exercise capacity in ApHCM. **METHODS:** Twenty-two patients with ApHCM (17 male, mean age, 58  $\pm$  10) underwent supine bicycle exercise and two-dimensional and Doppler echocardiographic study at the same time. The mitral inflow velocities were traced and the following variables were derived: peak velocity of early ( $E$ ) and late ( $A$ ) filling and deceleration time ( $DT$ ) of  $E$  velocity.  $E'$  was measured at septal corner of mitral annulus by DTI from apical 4-chamber view. ProBNP was measured at the time of echocardiogram using a quantitative electrochemiluminescence immunoassay. **RESULTS:**  $E/E'$  correlated inversely with exercise duration ( $r^2=0.27$ ,  $p=0.014$ ). There was significant positive correlation between  $E'$  and exercise duration ( $r^2=0.23$ ,  $p=0.024$ ). However, no correlation was found between conventional Doppler indices, proBNP and exercise duration ( $E$ ,  $r^2=0.09$ ,  $p=0.19$ ;  $E/A$ ,  $r^2=0.05$ ,  $p=0.32$ ;  $DT$ ,  $r^2=0.02$ ,  $p=0.56$ ; Left atrial volume index,  $r^2=0.12$ ,  $p=0.12$ ; log proBNP,  $r^2=0.03$ ,  $p=0.41$ ). **CONCLUSION:** Unlike conventional Doppler indices and proBNP, the DTI derived indices ( $E'$ ,  $E/E'$ ), an estimate of myocardial relaxation and LV filling pressures, correlate with exercise capacity in patients with ApHCM, suggesting that abnormal diastolic function is an important factor limiting exercise capacity.

#### ORAL CONTRIBUTIONS

### 845 Computed Tomography: In What Ways Can Imaging Help Me Take Care of Patients?

Tuesday, March 09, 2004, 2:00 p.m.-3:30 p.m.  
Morial Convention Center, Hall D-1

2:00 p.m.

845-1

#### Higher Coronary Calcification Scores Improve Adherence to Cardiac Risk Factor-Modifying Behaviors

Nove K. Kalia, Loren G. Miller, Matthew J. Budoff, Harbor-UCLA Research and Education Institute, Torrance, CA

The data regarding compliance and Electron Beam Tomography (EBT) is mixed. We sought to measure whether showing coronary artery calcium results to patients has effect on behavioral lifestyle changes.

**Methods:** We evaluated the association between EBT and adherence to lipid lowering therapy and lifestyle modifications among consecutive patients referred for evaluation of coronary atherosclerosis. We hypothesized that patient knowledge of increasing CAC burden will be associated with improved patient adherence to coronary risk reducing behaviors, such as lipid lowering therapy, exercise, diet and smoking cessation. A total of 1215 consecutive asymptomatic patients referred for EBT risk assessment by their primary physician were sent a survey questioning them about health behaviors. Follow-up survey information was obtained in 981 of 1215 (81%) of patients, a mean of 3.6  $\pm$  2.1 years after the baseline scan. There were no differences in the prevalence of risk factors and CAC characteristics between responders and non-responders.

**Results:** Patients were divided into quartiles based upon CAC score (first quartile 0, second 1-59, third 60-285, fourth  $>286$ ). Patients in the first score quartile (0-1), had the lowest utilization of all lifestyle modifications between scans. Statin utilization, among those with high cholesterol, increased with increasing scores, increasing from 40% in quartile 1 to 79% in fourth quartile ( $p<0.001$ ). Dietary modification, cardiovascular exercise significantly increased over these same groups, with a trend towards higher incidence of tobacco cessation among patients with higher calcium scores (52% v. 74%,  $p=0.08$ ). **Discussion:** We believe that the improved adherence in our study most likely reflected that the patients' perceived threat of their atherosclerotic disease was changed after their EBT test. Additionally, because our patients were physician-referred for EBT assessment, increased and ongoing physician-patient dialogue concerning the patient's CAD

risks may have further reinforced the patients' adherence. This suggests that CAC may add motivation to asymptomatic patients recommended for lifestyle modification and drug therapy.

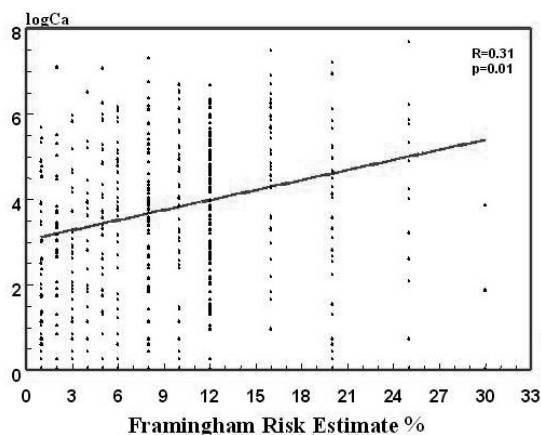
2:15 p.m.

845-2

#### Framingham Risk Estimate Is Weakly Correlated With Coronary Artery Calcification in Asymptomatic Population

Milind Y. Desai, Khurram Nasir, Joel B. Braunstein, Matthew J. Budoff, John A. Rumberger, Wendy S. Post, Roger S. Blumenthal, Johns Hopkins University, Baltimore, MD

**Background:** Both coronary artery calcification (CAC) and assessment of traditional risk factors using Framingham risk estimate (FRE) predict future cardiovascular events. The extent of relation between presence of CAC and FRE, however, has not been clearly defined. We assessed the strength of this relationship and evaluate whether CAC also provides independent additive information over that provided by FRE. **Methods:** We studied 5324 asymptomatic subjects (66% males, mean age 53  $\pm$  9 years) referred for electron beam tomography. We stratified patients into 3 groups: 1 ( $n=2595$ ) = low risk ( $<6\%$  FRE), 2 ( $n=2040$ ) = intermediate risk (6-20% FRE) and 3 ( $n=936$ ) = high risk ( $>20\%$  FRE). Abnormal coronary artery calcification (CAC) was defined as calcium score  $>75^{th}$  percentile based on gender and age. **Results:** Abnormal CAC was present in 13% patients in Group 1, 21% patients in Group 2 and 29% patients in Group 3. Groups 2 and 3 had significantly increased prevalence of abnormal CAC than group 1 ( $p<0.01$ ). Risk defined by FRE only weakly correlated with CAC, transformed to its log ( $r=0.31$ ,  $p<0.05$ , figure). **Conclusion:** In low risk asymptomatic individuals, prevalence of abnormal CAC significantly increases among patients categorized into intermediate and high-risk categories defined by FRE. At best, however, FRE is weakly correlated with presence of abnormal CAC. Quantification of CAC (particularly within the intermediate group) might yield incremental information to FRE and aid in improved risk stratification.



2:30 p.m.

845-3

#### Noninvasive Evaluation of Coronary Artery Plaque With ECG-Gated Multislice Computed Tomography

Shinro Matsuo, Yasuyuki Nakamura, Tetsuya Matsumoto, Ichiro Nakae, Terue Koh, Minoru Horie, Shiga University of Medical Science, Otsu, Japan

**Background;** With faster image acquisition times and thinner slice widths, multislice detector computed tomography (MSCT) allows visualization of human coronary arteries. The aims of this study are to evaluate the feasibility in determining coronary lesion configuration, including coronary plaque and calcification, stenosis, by ECG-gated MSCT. **Methods:** In 50 patients (35 male and 15 female, aged 65  $\pm$  9 years) with suspected obstructive coronary artery disease, ECG-gated MSCT angiography was performed with an 8-slice MSCT scanner (Aquilion, Toshiba, Japan). CT were performed with a multislice CT scanner with slices of 1mm width, 0.5mm reconstruction interval, pitch of 0.375, and 500 msec of gantry rotation. Visual coronary arteries were simulated in 3 coronary arteries. Conventional coronary angiographies were performed in all patients. Ten patients underwent intracoronary ultrasound (IVUS) and the characteristics of the coronary plaque were determined. The results were compared with the characteristics of IVUS. **Results:** Current MSCT allows visual coronary artery with good image quality. The overall sensitivity for diagnosing significant coronary stenosis among 490 segments were 80.2%, the specificity was 95.6%. The positive and negative predictive values were 84.9% and 96.2%, respectively. The accuracy of MSCT for detecting coronary stenosis is the highest in the left main trunk and left anterior descending coronary artery, and lowest in the circumflex coronary artery. Thirty-one plaques were analyzed. With IVUS, the plaques were classified as soft ( $n=10$ ), intermediate ( $n=8$ ), and calcified ( $n=13$ ). Using MSCT, soft plaques had a density of 17  $\pm$  24 HU, intermediate plaques of 98  $\pm$  21 HU and calcified plaques of 499  $\pm$  192. There were a significant difference of plaque density among three groups ( $p<0.01$ ). **Conclusion;** MSCT was feasible for the detection of coro-