Heart Rate Recovery as a Predictor of Mortality Independent of the Angiographic Severity of Coronary Disease
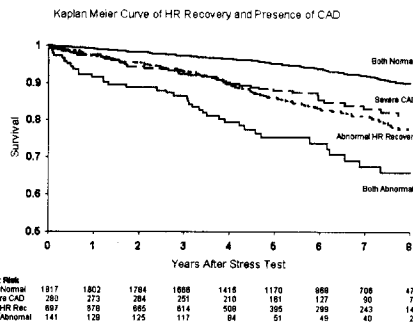
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Background: An attenuated decrease in heart rate after exercise, or heart rate recovery (HRR), has been shown to predict mortality. There are few data regarding its prognostic importance once angiographic severity of coronary artery disease (CAD) is accounted for.
Methods: We followed for 6 years 2935 consecutive patients who underwent symptom-limited exercise testing for suspected CAD and then had a coronary angiogram within 90 days. HRR was abnormal if $\leq$ 12 bpm during the first minute after exercise. Angiographic CAD was considered severe if the Duke Prognostic Weight Score was $\geq$ 42 (on a scale of 0-100), which corresponds to a level of CAD where revascularization is associated with better long-term survival.
Results: Severe CAD was presented in 421 patients (14%), while an abnormal HRR was noted in 838 (29%). There were 336 deaths (11%). Mortality was predicted by an abnormal HRR (hazard ratio [HR] 2.5, 95% CI 2.0-3.1, P<0.0001) and by severe CAD (HR 2.0, 95% CI 1.6-2.6, P<0.0001); both variables provided additive prognostic information (Figure).

Kaplan Meier Curve of HR Recovery and Presence of CAD

After adjusting for age, gender, standard risk factors, medications, exercise capacity, and LV function, abnormal HRR remained predictive of death (adjusted HR 1.6, 95% CI 1.3-2.0, P<0.0001); severe CAD was also predictive (adjusted HR 1.4, 95% CI 1.1-1.9, P=0.008).**Conclusion:** Even after taking into account angiographic severity of CAD, LV function, and exercise capacity, heart rate recovery is independently predictive of mortality.

Systolic Blood Pressure Recovery After Exercise as a Predictor of Mortality

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Background: An attenuated systolic blood pressure recovery following exercise has been associated with the severity of atherosclerotic heart disease. However, few studies have evaluated blood pressure recovery as a predictor of mortality. **Methods:** We followed 12,379 patients for 6 years who underwent symptom limited exercise testing. We excluded all patients receiving antihypertensive medication, as well as patients with valvular heart disease, emphysema, end stage renal disease, congestive heart failure and atrial fibrillation. Blood pressure recovery ratio was defined as the ratio of systolic blood pressure at 3 minutes into recovery to systolic blood pressure at peak exercise. This ratio has previously been shown to correlate with the angiographic severity of coronary artery disease. The ratios were then categorized into quartiles. **Results:** The blood pressure recovery ratios for each quartile 1 to 4 were 0.72±0.05, 0.82±0.02, 0.88±.0.02, and 0.99±0.07 respectively. Compared to those in quartile 1, patients in quartile 4 were older (54 vs. 51 years), more likely male (80% vs. 73%), had a higher resting systolic blood pressure (129 vs. 125 mm Hg), and were more likely to have an abnormal heart rate recovery of $\leq$ 12 beats per minute (20% vs. 13%), but did not differ in exercise capacity (10±2 METs). During follow up there were 430 deaths (3%). 5-year Kaplan Meier survival rates were 0.975, 0.974, 0.969 and 0.966 in quartiles 1 to 4 respectively (P=0.0003). Compared to patients in the lowest quartile of blood pressure recovery ratio, those in the highest quartile were at increased risk (hazard ratio 1.71, 95% CI, 1.31 to 2.24; p<0.001). However, after adjusting for age, gender, body mass index, resting heart rate and blood pressure, peak systolic blood pressure, heart rate recovery, exercise chronotropic response, cardiac history, and standard risk factors, the association was no longer present (adjusted hazard ratio of 1.05, 95% CI 0.8 to 1.38, p=0.74). **Conclusion:** In this low risk population, abnormal systolic blood pressure recovery after exercise did not predict mortality after correcting for differences in baseline and exercise characteristics.

Association of Educational Status With Heart Rate Recovery: A Population-Based Propensity Analysis

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Background: Poor educational status has been hypothesized to be associated with chronic stress and autonomic imbalance. Abnormal heart rate recovery after exercise reflects decreased vagal tone and is predictive of death.
Objective: To assess the association of educational level with abnormal heart rate recovery.

Methods: 5246 healthy adults from the Lipid Research Clinics Prevalence Study underwent exercise testing: 874 (17%) did not graduate high school, 1823 (35%) graduated high school but did not attend college and 2549 (49%) had at least some college education. An abnormal heart rate recovery was $\leq$ 42 beats per minute from peak exercise to 2 minutes of recovery based on prior prognostic validation.
Results: An abnormal heart rate recovery was more common among adults who did not graduate high school compared to those who attended at least some college (50% vs. 28%, OR 2.68, 95% CI 2.28 to 3.13, P < 0.0001). After adjusting for age, gender, race, occupation, body mass index, standard risk factors, and exercise capacity, failure to graduate high school remained associated with an abnormal heart rate recovery (compared to those who attended some college, adjusted OR 2.33, 95% CI 1.95 to 2.78, P < 0.0001). Furthermore, after using propensity scoring to match poorly educated subjects with better educated ones on over 20 covariates, lower educational status remained an independent risk factor for abnormal heart rate recovery (adjusted OR 1.93, 95% CI 1.56 to 2.40, P < 0.0001). During the 12-year follow-up, there were 327 deaths. Poor educational status was associated with an increased risk of mortality (hazard ratio 1.88, 95 % CI 1.43 to 2.48, P < 0.0001). After adjusting for age, gender, race, and abnormal heart rate recovery this association was attenuated (adjusted hazard ratio 1.29, 95% CI 1.00 to 1.67, P = 0.05).
Conclusion: Educational status is an independent correlate of abnormal heart rate recovery, even after accounting for multiple confounders by propensity analysis. Our data are consistent with the hypothesis that lower educational levels are correlated with prognostically important disturbances of autonomic function.

POSTER SESSION

1040   Basic Cardiovascular Physiology: Effect of Advancing Age

Sunday, March 17, 2002, Noon-2:00 p.m.
Georgia World Congress Center, Hall G
Presentation Hour: Noon-1:00 p.m.

Gender But Not Age Affects Cardiovascular Performance During Mental Stress in Healthy Subjects 20-93 Years Old

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Background: Advancing age is accompanied by major changes in cardiovascular performance during aerobic exercise, thought to be mediated largely by a blunted response to catecholamines. Whether age has a similar effect on cardiac function during mental stress (MS), a milder catecholamine stimulus, is not well defined.
Methods: Accordingly 107 healthy volunteers 20-93 years old from the Baltimore Longitudinal Study of Aging screened to exclude cardiovascular disease by history, physical exam, resting and maximal exercise ECG (and if > 40 years old, exercise thallium scans) underwent gated cardiac blood pool scans with Tc99m before and during the Stroop color word test.
Results: In the overall group, MS elicited significant increases in systolic (13±10) and diastolic (7±6mmHg) blood pressures, heart rate (12±10 bpm), cardiac index (0.7±0.6 1/min), each < .0001, a small rise in ejection fraction (EF), (1.4± 5 points, p=.005) but no changes in left ventricular (LV) volumes. None of the induced hemodynamic changes was related to age by linear regression analysis. When the hemodynamic response of the 52 women was compared with that of the 55 men, the EF increased during MS in women (3.1±5.2points p<.01) but not in men (-0.2±4.4 points, p=NS), despite similar changes in heart rate, blood pressure and end-diastolic volume. **Conclusion:** Thus, in carefully screened normal subjects, the LV response to mild MS appears to be unaffected by age but is greater in women than in men despite similar gender changes in heart rate, preload and afterload.

The Aged Dog With Diastolic Dysfunction Develops Systolic Dysfunction After Induction of Diabetes

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In the young canine, induction of diabetes (D) results in increased left ventricular (LV) diastolic stiffness due to advanced glycation of interstitial collagen (Avendano, G). The normal aged dog exhibits diastolic stiffness in the basal state (Asif, M 2000). To evaluate the interaction of diabetes and aging eight male aged dogs were serially studied at baseline, post-D and post treatment with 3-phenacyl-4, 5-dimethylthiazolium chloride (ALT-711). LV and aortic dimensions were measured by ECHO and pressures obtained from a micromanometer catheter before and after volume expansion with dextran. To determine the influence of D on LV function in the aged, alloxan 30 mg/kg I.V. was given. HbA$_{1c}$ was raised from 2.2± 0.1% to 5.6± 0.3% throughout the diabetic state. After 5 months LV function was determined in the anaesthetized dog (Table). For the following month these animals were fed ALT-711, a collagen cleavage agent, 1 mg/kg/day to determine if aortic and LV diastolic stiffness in D were changeable after treatment and the influence on aortic-ventricular functions (Table). Increased aortic stiffness and reduction of ejection fraction (EF) in the aged D were associated with decreased aortic stiffness and normalization of EF after treatment. Whether intrinsic changes of LV contribute to the effects of reduced