

transmission imaging does not adversely effect the emission data. Additionally, AC results in more individual segments and overall pt studies being interpreted as normal.

951-105 Quantitation of Regional Ejection Fractions Using Gated Tomographic Imaging With Tc-99m-Sestamibi

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Gated single photon emission computed tomographic (SPECT) sestamibi imaging allows simultaneous assessment of myocardial perfusion and left ventricular function. We evaluated a technique based upon edge detection to quantify regional ejection fractions (EF) in 15 subjects without cardiac pathology and 24 patients following myocardial infarction (MI). After tomographic reconstruction of gated short axis slices, identification of endocardial borders was made by a standard edge detection program in systole and diastole in each of five selected slices. Regional EF's were calculated for five regions within each slice. Myocardial perfusion was quantitated in the same regions. Ten patients underwent echocardiographic regional wall motion (RWM) analysis which was compared to corresponding regional EF results. *Results:* A high degree of interobserver reproducibility in the assessment of regional EF's was found with r values ranging from 0.94 to 0.98. In patients with anterior and inferior MI, regional EF's were abnormal in the anterior and septal, and inferior and lateral regions, respectively. Regional EF's correlated significantly with regional perfusion in anterior ($r = 0.63, p < 0.0001$), lateral ($r = 0.40, p < 0.0001$), and inferior walls ($r = 0.38, p < 0.0001$). There was a significant association between regional EF and echocardiographic RWM assessment at the base ($p < 0.0001$), mid ventricle ($p = 0.004$), and apex ($p = 0.0003$). *Conclusions:* Gated tomographic images with technetium-99m-sestamibi can provide reproducible quantitative segmental regional EF's for multiple left ventricular slices that are significantly associated with subjective RWM assessment by echocardiography.

951-106 Artificial Neural Network for Automatic Interpretation of Myocardial Perfusion SPECT

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Interpretation of myocardial perfusion SPECT (MPS) is mainly subjective, whereas quantitative programs (QP) are currently still not in widespread clinical use. We developed a novel, flexible, non-rule based artificial neural network (NN) which can uniquely "learn" from experience. A group of 140 pts who underwent exercise sestamibi SPECT comprised our training set (TRG), and a different group of 97 pts was used for testing (TSG). Defect extent and severity data were derived from raw circumferential profiles, produced by an optimized QP (CEqual), and used as NN inputs. Exercise scans were visually scored (2 experts) in 20 myocardial segments (5 point score: 0 to 4 = normal to no uptake) for use as NN and QP targets. Abnl scan was defined by a summed score of ≥ 2 for ≥ 2 segments. NN output scores were compared to visual scores. The NN results were also compared to CEqual outputs for the same TSG. The overall sensitivity/specificity for the NN and CEqual were 85/83% and 92/77%, respectively ($p = ns$). Overall accuracy results are as follows:

Accuracy (%)	Total	ant	ant-sept	inf-sept	inf	inf-lat	ant-lat	apx
NN	83	77	86	77	86	85	88	76
CEqual	81	86	82	76	86	78	77	78

ROC curves for the NN and for CEqual show comparably high values. Conclusion: these initial results suggest that our NN issuitable for accurate identification of MPS defects.

951-107 Accuracy and Reproducibility of Automated Tomographic Ventricular Function Measurements

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Both manual and automated methods for computing left ventricular (LV) end-diastolic (ED) volume, end-systolic (ES) volume and ejection fraction (EF) from scintigraphic gated tomograms have been developed but reproducibility and accuracy of measurements versus other methods are not well known, particularly since automated programs can be confounded by conditions such as reduced regional myocardial perfusion. In automated processing of horizontal and vertical long axis Tc-99m sestamibi gated myocardial perfusion tomograms of 145 patients (pts), experienced observers judged it necessary to alter: (1) ED or ES frames in 7% of pts, (2) endocardial borders in 14%,

and (3) LV cavity center locations in 28%. Agreement among independent observers using the software demonstrated correlation by linear regression of $r = 0.92$, and compared to manual EF determinations as $r = 0.90$. Regression analysis yielded $r = 0.87$ for tomographic EF vs. first pass EF in 67 pts. Linear regression for tomographic EF vs. gated equilibrium EF in 77 pts was $r = 0.87$, and similar correlation coefficients were computed for these pts when subgrouped according to whether changes were or were not needed for LV center location ($r = 0.91$ vs. $r = 0.86$), or endocardial borders ($r = 0.87$ vs. $r = 0.89$); and were likewise similar for pts grouped according to ED volume greater or less than the median value of 87.5 ml ($r = 0.89$ vs. $r = 0.87$). We conclude that our automated algorithms are reproducible and accurate compared to independent EF methods, and that changes needed in LV center location for over 25% of pts cause no degradation in EF accuracy.

951-108 Absolute Right and Left Ventricular Volume and Ejection Fraction Measurements by Tomographic MUGA

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To validate tomographic radionuclide gated equilibrium blood pool scintigraphy (TMUGA) absolute volume and ejection fraction measurements, gradient-echo MRI, conventional first pass radionuclide (FP) and planar gated equilibrium blood pool (PMUGA) scintigraphy were performed. Ten patients with normal and abnormal ventricular function had TMUGA and MRI. Ten patients also had TMUGA and FP. TMUGA was acquired using a 3-headed camera and 16 gated intervals. TMUGA ventricular volumes were calculated by Simpson's rule with regions defined by 1) phase analysis to separate atria and ventricles 2) threshold to define ventricular free borders and 3) visual inspection to define interventricular septum. Cardiac phantom studies were performed to obtain appropriate volume threshold for patient TMUGA. As previously validated, MRI studies were acquired on a 1.5 Tesla system with a multiphase, breath-hold, segmented k-space technique. MRI volumes were calculated by Simpson's rule using 12-16 6 mm thick parallel short axis slices and regions defined by a semi-automatic contour tracking routine. Gated FP radionuclide angiography and PMUGA were performed for RVEF and LVEF.

Volume measurements at end-systole and end-diastole by TMUGA showed good correlation with MRI for RV ($r = 0.91$, slope = 0.90, SEE = 15.7) and LV ($r = 0.96$, slope = 0.88, SEE = 18.2). TMUGA also showed good correlation for both RVEF and LVEF.

	TMUGA RVEF			TMUGA LVEF			
	r	slope	SEE	r	slope	SEE	
MRI	0.88	0.79	6.0	MRI	0.94	1.10	9.0
FP	0.86	1.2	7.9	PMUGA	0.97	1.23	6.2

TMUGA shows good accuracy in simultaneous measurements of absolute right and left ventricular volumes and ejection fractions.

952 Hypertension: Basic and Clinical

Tuesday, March 26, 1996, 9:00 a.m.--11:00 a.m.
Orange County Convention Center, Hall E
Presentation Hour: 10:00 a.m.--11:00 a.m.

952-109 Outcome in Medically Managed Second Opinion Patients With Coronary Artery Disease and Short Exercise Duration

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An exercise treadmill test (ETT) duration of less than 6 mins (standard Bruce protocol) is viewed as a poor survival predictor in patients with coronary artery disease (CAD). To determine the prognosis of short exercise duration (SED) in patients with documented CAD, referred for a second opinion prior to bypass grafting, we analyzed ETT and clinical data with a mean follow up period of 6.1 yrs (SD 5.7) in 50 consecutive pts (mean age was 69.3 yrs, 46 M), who received medical treatment. Clinical and ETT data revealed prior myocardial infarct (MI) n = 25, a mean EF of 45%, a peak HR of 113.3, mean resting BP of 134/75, peak BP of 139/74 and a mean ST segment depression of 1 mm. A cardiac event was defined as cardiac death, nonfatal myocardial infarct, congestive heart failure (CHF) or revascularization procedure: PTCA or CABG. *Results:* Cardiac events occurred in 22 pts, with nonfatal MI (n = 7), CHF (n = 6) and revascularization (n = 15). Cardiac mortality was 12% (n = 6), with fatal MI (n = 1), 2 death peri-angioplasty and 3 peri-operatively. Multivariate significant ($p < 0.05$) adverse prognostic predictors (Cox) were presence of rest angina, b-blocker therapy and pre ETT use of s.l. nitro.

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The actual exercise duration, ETT variables, other clinical history or medical regimens were not predictive. Free of cardiac events were 56% (CI 53–62) at 5 yrs and 47% (CI 33–68) at 10 yrs. The survival rate was 95% (CI 0.89–1.0) at 5 yrs and 85% (CI 0.71–1.0) at 10 yrs. **Conclusions:** 1. SED alone does not constitute an adverse outcome. 2. In second opinion CAD patients managed with medical therapy and a short exercise duration, mortality is not predicted by ETT variables, but by type of angina and medical regimen.

952-110 Dipyridamole Induced ST-segment Depression Predicts Ischemia in Patients With Left Ventricular Hypertrophy by ECG

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ST-segment depression (STdpr) in the presence of LVH by ECG is an unreliable marker of ischemia during exercise stress testing. Dipyridamole (DP) induced STdpr is a highly specific marker of ischemia, however its significance is unknown in patients (pts) with LVH by ECG. We studied 484 consecutive pts undergoing DP perfusion imaging (0.57 mg/kg over 4 min with sestamibi injection at 8 min) for development of ≥ 1 mm horizontal or downsloping STdpr. An additional 1 mm STdpr was required if baseline STdpr was present. LVH was defined by standard ECG criteria. Ischemia was defined as any new perfusion defect compared to the resting scan. Pts with LBBB or ventricular paced rhythm (n = 31) were excluded. Four groups were identified: LVH with STdpr, LVH without STdpr, STdpr without LVH, no STdpr no LVH. Antianginal and digoxin use was similar among groups. STdpr occurred in 22/78 (28%) pts with LVH versus 35/375 (9.3%) pts without LVH (p < 0.001). Ischemia occurred in 15/22 (68%) LVH pts with STdpr versus 14/56 (25%) LVH pts without STdpr (p = 0.002). Ischemia frequency was similar in STdpr pts regardless of LVH by ECG (p = 0.28). DP infusion increased heart rate and rate-pressure product (RPP) and decreased blood pressure in each group. LVH pts with STdpr had higher resting and peak heart rates and RPP as compared to LVH pts without STdpr (all p < 0.04). No significant difference in resting and peak heart rate and RPP was present among STdpr pts with or without LVH. Chest pain occurred with higher frequency in LVH pts with STdpr vs without STdpr (11/22 vs 12/56; p < 0.02) but with similar frequency compared to STdpr pts without LVH.

Conclusions: (1) DP induced STdpr is more frequent in pts with vs without LVH by ECG. (2) The frequency of ischemia and hemodynamic effects induced by DP are similar in STdpr pts independent of LVH by ECG. (3) DP induced STdpr in pts with LVH by ECG is predictive of ischemia.

952-111 Mechanism of Preserved Exercise Capacity in Patients With Reduced Left Ventricular Function

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To elucidate the mechanism of preserved exercise capacity in patients with reduced left ventricular (LV) function, 71 patients with myocardial infarction underwent a symptom-limited invasive cardiopulmonary exercise test with a cycle ergometer in a supine position. Patients were divided into two groups according to LV ejection fraction (EF) at rest; Group A (n = 20): EF > 40% (avr. 56 ± 6%), Group B (n = 51): EF \leq 40% (avr. 31 ± 7%). Cardiac output and LV pressure were measured with a Swan-Ganz catheter and a tipped catheter, respectively, at rest and during exercise. LV stiffness index was calculated as (left ventricular end-diastolic pressure – minimum pressure)/stroke volume index (SI).

	CI	SI	HR	a-vDO2	VO2	Stiffness
A Rest	4.1 ± 0.8	56 ± 9	75 ± 11	3.2 ± 0.8	3.6 ± 0.8	0.2 ± 0.1
Peak	8.1 ± 1.9	65 ± 12	125 ± 20	8.1 ± 1.8	16.5 ± 4.9	0.3 ± 0.1
B Rest	3.7 ± 0.8*	48 ± 8*	78 ± 10	3.7 ± 0.9*	3.5 ± 0.7	0.3 ± 0.1*
Peak	6.7 ± 1.5*	53 ± 10*	128 ± 18	9.0 ± 1.5*	16.3 ± 4.4	0.4 ± 0.1*

CI: cardiac index (L/min/m²), SI (ml/m²), HR: heart rate (bpm), a-vDO2: arteriovenous O2 difference (ml/dl), VO2: O2 uptake (ml/min/kg), Stiffness: LV stiffness index, Peak: peak exercise. *p < 0.05, *p < 0.01 vs. Group A.

Patients with reduced EF showed not only reduced CI and SI but also impaired diastolic function both at rest and during exercise. However, peak VO2 was comparable to that of the patients with higher EF, because a-vDO2 fully compensated the reduced CI. **Conclusion:** In patients with reduced LVEF, exercise capacity is preserved by a compensatory increase in a-vDO2. HH and LV diastolic function are not likely to play a compensatory role in this setting.

952-112 Maximal Exercise Testing Early After Myocardial Infarction — Better to Predict Cardiac Events?

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The aim of this prospective study was to evaluate if predischARGE maximal exercise treadmill testing (ETT) after myocardial infarction (MI) is superior to the classic low level (HR < 70% of age predicted) ETT, for risk stratification.

We studied a group of 124 consecutive patients (P), 111 men and 13 women, mean age 56.1 ± 9.7 years, admitted with MI (52 inferior, 48 anterior, 24 non-Q) who performed a predischARGE (10.4 ± 2.3 days) symptom limited ETT, without anti-ischemic medication, using a modified Bruce protocol. There was no major complications. We have registered in all patients some variables (exercise duration, symptoms, HR, systolic BP, double product, ST segment depression and arrhythmias) at HR = 70% and at peak exercise. Only 13 P had not achieved a HR > 70% of predicted. 23 P had positive (ST-segment depression with or without chest pain) ETT at HR < 70% and 18 additional P had positive ETT at HR > 70%. In the follow-up (mean 20.7 ± 5.2 months) 51 P suffered cardiac events (recurrent angina, reinfarction, cardiac death, PTCA, CABG). Of these 51 P only 18 had a positive test at low level but 32 P had positive test at peak exercise. 33 P with negative ETT at HR < 70% had suffered events versus only 19 P with negative maximal ETT. 14 of the 18 P (78%) with positive ETT only after HR > 70% (P with negative low level ETT) had cardiac events in the follow-up.

PredischARGE ETT for detection cardiac events in the follow-up:

	HR < 70%	Maximal
Sensitivity	0.35	0.63
Specificity	0.93	0.88
Predictive Value (+)	0.78	0.78
Predictive Value (-)	0.67	0.77

Conclusion: PredischARGE maximal ETT appears to be safe and better than low level ETT for risk stratification after MI.

952-113 Relationship Between Resting Blood Pressure and Perception of Angina Pectoris During Exercise

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Previous studies in animals and humans have shown decreased pain perception in hypertensives. To test the hypothesis that resting blood pressure influences anginal pain perception during exercise, we reviewed 4723 exercise treadmill test results performed at UNC Hospitals during 1990–1994. All tests were interpreted by one cardiologist. 1144 tests were positive, defined as 1 mm horizontal or downsloping ST segment depression at 0.08 seconds after the J-point. Patients with conditions that affect anginal perception (diabetes mellitus, post CABG), exercise protocol other than Bruce, who were taking antianginal medication or digoxin were excluded. Patients with resting ECG abnormalities (LVH, LBBB, WPW), ECG changes with posture or hyperventilation were also excluded. Two hundred thirty five patients with positive tests remained after exclusion. Hemodynamic data were obtained at rest and during exercise (2 minutes into each stage). Angina was reported in 65 patients. Compared to patients with angina, patients without angina had a higher resting systolic (135 ± 1.6 vs 128 ± 2.2 mmHg, p = 0.02) and diastolic (83 ± 0.8 vs 80 ± 1.3 mmHg, p = 0.04) blood pressure without any differences in resting heart rate (79 ± 0.9 vs 78 ± 1.8bpm, p = ns). Time to onset of 1 mm ST depression and double product at 1 mm ST depression were the same for both groups. Fourteen out of 74 patients (19%) with resting SBP < 140 mmHg had angina during exercise whereas 51 out of 161 (32%) patients with resting SBP \geq 140 mmHg had angina (p = 0.04). In conclusion: patients with higher resting blood pressure have less frequent angina during exercise. Thus resting blood pressure appears to be related to pain perception in patients with CAD.

952-114 Prediction of Maximal Oxygen Consumption by Six Minute Walk Testing in Patients With Congestive Heart Failure

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Maximal oxygen consumption (VO₂max) is widely used for risk stratification in CHF but is expensive and not widely available. The 6 minute walk test (6MW) provides an inexpensive and readily available measure of submaximal exercise capacity, and may be closely correlated to VO₂max. Therefore, we measured 6MW and VO₂max during treadmill exercise on CHF patients referred for functional assessment; data on 237 pts (190 men, 47 women; age 50.2 ± 11.4 years) who achieved R values \geq 1.1 were included in this

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