58 patients had painful and 31 painless myocardial ischaemia. Clinical and demographic characteristics as well as the coronary artery anatomy were similar in both groups. Compared with painful, patients with painless ischaemia achieved a better exercise performance with a greater exercise duration (P < 0.001) and higher maximum heart rate-blood pressure product (P < 0.001). New wall motion abnormalities were seen in 84 (63%) patients with painful against 17 (55%) with painless ischaemia (P < 0.001). The total ischaemic score was greater in patients with painful versus painless ischaemia (15.9 ± 3.7 vs 12 ± 1.4, P < 0.001) with a greater number of ischaemic myocardial segments in painful than in painless ischaemia (101 vs 21, P < 0.001).

Conclusion: Patients with painless ischaemia frequently have regional myocardial dysfunction on exertion detected by echocardiography but painful episodes are accompanied by a greater magnitude of myocardial dysfunction.

**978-63 The Value of Exercise Testing for Predicting the Outcome in Patients with Congenital Third Degree A-V Block**

Amy K. Hara, Timothy F. Christian, Mona Hoofnsperger, David G. Hodg, David L. Hayes. Mayo Clinic, Rochester, MN

Ambulatory monitoring (AM) has been reported to have important prognostic value in patients with third degree congenital heart block (CHB). The purpose of this study was to compare clinical, electrocardiographic, exercise (Ex), and ambulatory monitoring variables in predicting outcome in patients with CHB. Multiple clinical (age, gender, race, associated congenital defects, symptoms), and electrocardiographic variables (rest heart rate [HR], QRS duration, atrial rate, resting arrhythmias) were analyzed for 40 patients with CHB but without a pacemaker. Exercise treadmill testing was performed in 17 patients and ambulatory monitoring in 21 patients. Events were defined as cardiac death (n = 2) and/or pacemaker insertion (n = 27). The median follow-up interval was 8 years. No clinical or rest electrocardiographic variables were associated with subsequent events, although there was a trend for the presence of symptoms and low resting HR (P = 0.07 for both). In contrast to ambulatory monitoring, exercise testing was significantly associated with events:

<table>
<thead>
<tr>
<th>Events</th>
<th>No Events</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak HR</td>
<td>99 ± 24</td>
<td>135 ± 32</td>
</tr>
<tr>
<td>(Peak-rest) HR</td>
<td>47 ± 21</td>
<td>67 ± 17</td>
</tr>
<tr>
<td>Rate-pressure product</td>
<td>16,100 ± 5670</td>
<td>23,450 ± 1640</td>
</tr>
<tr>
<td>AM variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average HR</td>
<td>51 ± 12</td>
<td>58 ± 17</td>
</tr>
<tr>
<td>Minimum HR</td>
<td>38 ± 5</td>
<td>45 ± 12</td>
</tr>
<tr>
<td>Maximum HR</td>
<td>83 ± 24</td>
<td>77 ± 17</td>
</tr>
</tbody>
</table>

Conclusions: Clinical and rest electrocardiographic variables, by themselves, are not helpful in predicting outcome in pts with CHB. The addition of exercise testing is more closely associated with outcome than ambulatory monitoring in patients with CHB.

**978-64 Does Cardiac Rehabilitation Improve Blood Viscosity in Patients with Ischemic Heart Disease?**

Glenn N. Levine, Carol O'Malley, Gary J. Balady. Boston University Medical Center, Boston, MA

The importance of blood viscosity in ischemic heart disease is becoming increasingly well established. Blood viscosity directly affects shear rates in the coronary arteries and perfusion pressure across coronary stenoses. Abnormalities of blood rheology, particularly elevated whole blood viscosity (WBV), have been associated with coronary artery disease (CAD), and have been prospectively shown to be an independent predictor of adverse cardiac events. There is, as yet, no established method for modifying this newly established risk factor, although regular exercise has been shown to improve blood viscosity in healthy subjects. To determine if exercise training, as prescribed in standard cardiac rehabilitation programs, has beneficial effects on blood viscosity in patients with CAD, we prospectively studied WBV and the factors that affect it, as well as exercise tolerance (ETT), before and after a ten week program of moderate intensity dynamic exercise in fifteen patients (aged 59 ± 8). WBV was measured in triplicate at six different physiologic shear rates. There were no intercurrent events or medication changes during the study period.

**The Magnitude of Myocardial Dysfunction is Greater in Painful than in Painless Myocardial Ischaemia. An Exercise Echocardiographic Study**

Petros Nihoyannopoulos, Antonis Marsonis, Jayshree Joshi, George Athanassopoulos, Celia M. Oakley. Clinical Cardiology, Hammersmith Hospital, R.P.M.S., London, England

Exercise echocardiography was performed in 89 consecutive patients (mean age 59.3 ± 8.2 years) with significant coronary artery disease and positive exercise stress test to assess the presence and extent of inducible myocardial dysfunction during painful and painless (silent) myocardial ischaemia. Patients were on no antilangiral medication and were divided into silent versus painful cohorts following the outcome of symptom limited treadmill exercise test. No patients had previous coronary artery bypass surgery or myocardial infarction. Images were acquired on digital format before and immediately after treadmill exercise testing.

**Topics in Exercise Physiology and Exercise Testing**

Tuesday, March 21, 1995, 3:00 p.m.-5:00 p.m. Ernest N. Morial Convention Center, Hall E Presentation Hour: 3:00 p.m.-4:00 p.m.
The standard ten week cardiac rehabilitation program of moderate intensity dynamic exercise leads to a highly significant improvement in exercise tolerance, but does not have a beneficial effect on blood viscosity in patients with ischemic heart disease.

**978-65**

**Exercise Forearm Vascular Responses in Patients Studied 7 Days After Myocardial Infarction**

Helen L. Thomson, Suhas S. Lale, John J. Atherton, Karen N. Wright, G.W. Muehle, Michael P. Hennan. Cardiology Department, Royal Brisbane Hospital, Brisbane, Australia

**Background:** We have reported that exercise hypotension in patients with ischemic heart disease may be due to abnormal vasodilation. Whilst exercise hypotension is not common in post-infarction patients, we hypothesised that forearm vascular responses may commonly be abnormal. We assessed the frequency of abnormal forearm vascular responses in an unselected group of patients studied 7 days post myocardial infarction and the association with exercise blood pressure (BP) responses and with baroreceptor gain.

**Method:** Forty consecutive consenting patients (26 male 4 female age 33-74 mean 56.2 years) were studied 7 days post myocardial infarction and were compared with 20 healthy controls (14 male 6 female age 44-69 mean 56.2 years). All subjects underwent assessment of changes in forearm vascular resistance (FVR) by venous occlusion plethysmography during semi-erect exercise, BP recordings during erect treadmill exercise, and baroreceptor gain assessed by the change in RR interval per unit change in blood pressure induced by phenylephrine (standard phenylephrine ramp method).

**Results** (expressed as mean ± SD): FVR increased during exercise by 41 ± 67% in patients versus 124 ± 110% in controls (p < 0.001), and fell in 12 patients. Using an increase of 15% (± one standard deviation below the mean for the controls) as the cut-off for normality, 15 patients exhibited abnormal exercise vascular responses. Exercise hypotension was demonstrated in 4 patients of all whom had abnormal forearm vascular responses. Baroreceptor gain was lower in patients with abnormal forearm vascular responses than those with normal forearm vascular responses (24 ± 62 mmHg vs 73 ± 87 msec/mmHg, p = 0.04).

**Conclusions:** Impaired forearm vasoconstriction or vasodilation during leg exercise is common in patients studied 7 days post MI, even in patients without exercise hypotension and is associated with a low baroreceptor gain.

**Exercise hypotension may only result in patients with abnormal forearm vascular responses, if they are unable to augment cardiac output.** The absence of exercise vascular responses in the majority of these patients implies a vigorous cardiac output response.

**978-66**

**Prolonged Bed Rest Impairs Response of the Small Arteries to Cold Pressor Test**

Fumiyoshi Watanabe, Katsu Takenaka, Yoji Suzuki, Yusihito Haruna, Kana Kuriyama, Seiji Iwamoto, Tsutomu Igarashi, Kiyoshi Kawakubo, Atsuki Gunji. University of Tokyo, Tokyo, Japan

Although most of the effects of prolonged bed rest on cardiovascular system is considered to be mediated by autonomic nervous system, there has been no evidence of change in α adrenergic activity. Cold pressor test has been known to increase vascular resistance through a α adrenergic stimulation. To assess if changes in α adrenergic activity occurs after prolonged bed rest, blood flow velocity of the proper palmar digital artery of the index finger (resistance vessel) was measured during 90 seconds of cold pressor test by pulsed Doppler ultrasound using a 7 MHz linear transducer in 10 healthy volunteers before and after 20 days of strict horizontal bed rest. Lower body negative pressure (LBNP) test was performed to measure LBNP tolerance time as an indicator of orthostatic tolerance.

Flow velocity decreased during the first 45 seconds of cold pressor test both before and after bed rest, and decreases in peak flow velocity were more prominent (p < 0.05) before bed rest (−38 ± 25%) than after bed rest (−48 ± 20%). After 20 days bed rest, LBNP tolerance time shortened (p < 0.02) from 19.5 ± 14.5 min to 1.0 ± 0.5 min in all but one subject who demonstrated prominent decrease in peak flow velocity during the first 45 seconds of cold pressor test. During the latter 45 seconds of cold pressor test, recovery of peak flow velocity was found in 7 subjects before bed rest, but in only 2 subjects after 20 days bed rest (p < 0.05).

In conclusion, 20 days bed rest impairs response of the small digital arteries to cold pressor test, which suggests that an adrenergic response diminishes after prolonged bed rest.

**978-67**

**Can Post-Stenotic Coronary Blood Flow be Increased by Exercise?**

Herbert J. Geschwind, Jan Kvasnicka, Ahmed Eghidal, Jean L. Dubois-Randé, Patrick Dupuy. University Hospital Henri-Mondor, University of Paris XI, Créteil, France

The ability of post-stenotic coronary blood flow to increase at exercise is one of the major determinants of the severity of coronary artery stenosis. Few studies have been performed on the changes induced by physical exercise on coronary blood flow using invasive methods. To assess the response of the coronary circulation to exercise distal to stenosis, coronary blood flow was measured at rest and during a supine bicycle exercise. Exercise was started at a workload of 30 W with a resistance increase in 30 W increments every 3 min to a maximum of 90 W. Coronary blood flow was derived from blood flow velocity measurements using a 15 MHz Doppler-tipped 0.014 inch guidewire and cross sectional area (CSA) measured at the site of the Doppler sensor using quantitative coronary angiography (QCA) according to the formula: CBF (ml/min) = APV/2 (cm/sec) x CSA (mm²) x 0.6 where APV is the time-average peak velocity and 0.6 the conversion factor for mm²/cm² and min/sec. The measurements were performed distal to a 78 ± 14 percent diameter stenosis in 25 patients aged 57 ± 9 years submitted to PTCA. The site of stenosis was the left anterior descending (n = 15) or the left circumflex (n = 10) coronary artery. No complication occurred during the procedure.

**Results:**

- Peak VO₂ (ml/kg/min) 23.8 ± 6.93 31.6 ± 6.04 <0.001
- Heart rate (bpm) 72 ± 12 88 ± 13 p < 0.001
- Mean arterial pressure (mmHg) 82 ± 12 103 ± 17 p < 0.001
- Central venous pressure (cP) 3.1 ± 2 3.6 ± 2.4
- CBF 18 ± 6 31 ± 11 p < 0.01 vs rest

**Conclusions:** 1. Assessment of coronary blood flow at exercise is feasible and safe during PTCA; 2. Exercise is able to significantly increase the post-stenotic coronary blood flow; 3. Further studies are required to determine whether this increase is sufficient for adequate blood supply to the myocardium.

**978-118**

**Exercise Capacity and Coronary Flow Reserve in Patients with Intermediate Coronary Stenoses**

James D. Joye, Angel R. Flores, Judith E. Orie, Nathaniel Reichek, Douglas S. Schulman. Medical College of PA, Pittsburgh, PA

In patients with coronary disease, exercise time is a predictor of disease severity. More severe disease is associated with shorter exercise time due to greater ischemia. In patients with intermediate coronary stenoses, however, it is unclear whether stenosis severity predicts functional effects. Thus, we examined the relationship between exercise time and the angiographic and physiologic significance of 25 intermediate coronary stenoses (40–70%). Using an intracoronary Doppler flow wire we measured coronary flow reserve (CFR) as the ratio of adenosine induced hyperemic coronary flow velocity to resting velocity. Stenosis severity was determined by quantitative angiography. Patients subsequently underwent maximal exercise testing on a Bruce protocol. No patient had left ventricular dysfunction, ischemia in other vascular distributions or other diseases known to limit exercise capacity. Exercise time was normalized for age and gender according to the method of Bruce. Total exercise time ranged from 3.9 to 12.8 min while normalized time ranged from 37 to 152% of predicted. CBF ranged from 1.0 to 3.5 (normal > 2.0) and was directly related to exercise time (r = 0.7, p < 0.0001, SEE = 2.1) and normalized exercise time (r = 0.7 p < 0.0001, SEE = 2.5). Normalized exercise time was 72 ± 21% of predicted in patients with an abnormal CFR vs 125 ± 23% of predicted in those with normal CFR (p < 0.0001). There was no relationship between angiographic percent stenosis and exercise time (r = -0.01) or normalized exercise time (r = -0.01). Normalized exercise time was ≥ 100% of predicted in 9 of 11 patients with a normal CFR, and <100% in 13 of 14 patients with abnormal CFR. The sensitivity, specificity and predictive accuracy of normalized exercise time for CFR were 93%, 82% and 88%, respectively. Thus, in patients with intermediate coronary stenoses and no other exercise limitations, treadmill exercise time is a useful marker of the physiologic severity of disease.