function. Our method is useful for a quantitative evaluation of orthostatic hypotension.

Although dynamic changes in heart rate play an important role in stabilizing arterial pressure (AP), little is known about roles of vagal and sympathetic efferents in heart rate control. The purpose of this study was to evaluate the respective roles against orthostatic stress using a white-noise system identification approach.

In 15 normal subjects (male, 28±7 years), we measured AP and R-R intervals (RRI) during random head-up tilting. According to a quasi-white noise, we altered the tilt angle between 0-30° every 8 sec using an electrically driven head-up tilt table. We computed the transfer function from AP change to RRI change, and estimated the step responses of RRI change to the sudden AP rise. We repeated the same procedures after atropine infusion (0.04 mg/kg, i.v.) to block the vagal effect, and then after trimethaphan infusion (0.1 mg/kg/min, i.v.) to nullify the sympathetic effect.

The step response function showed that the sudden AP rise of 1 mmHg quickly increased RRI by 8.2 msec in control, slowly by 4.0 msec after atropine, and by 2.0 msec after trimethaphan.

In conclusion, the vagal efferent contributes to a quick change in heart rate against the postural AP change.

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Key Words: Autonomic Nervous System, Heart Rate, Orthostatic Stress

**OR-30**

DIFFERENT ROLES OF VAGAL AND SYMPATHETIC SYSTEMS IN HEART RATE CONTROL FOR STABILIZING ARTERIAL PRESSURE AGAINST ORTHOSTATIC STRESS IN HUMANS

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The effect of centrally or peripherally acting antihypertensive agents on cardiac autonomic balance has not been evaluated. Assessment of heart rate variability (HRV) is a useful non-invasive way to evaluate cardiac autonomic balance. The aim of this study was to compare the effect of a central sympathetic inhibitor (moxonidine) against that of a peripheral inhibitor (nebivolol - a b1-blocker), on arterial blood pressure (BP) and HRV in patients with mild to moderate essential hypertension.

Twenty-seven patients were randomized to receive either moxonidine 0.4–0.6 mg once daily (7 men and 5 women, mean age 50±2.6 years) or nebivolol 2.5–5 mg once daily (9 men and 6 women, mean age 53±6 years) for one month, to achieve a target diastolic BP <90 mmHg. BP was measured with sphygmomanometry and HRV parameters, in the time and frequency domain, were estimated from 24-hour Holter recordings. Two independent investigators blinded to treatment assignment performed data analysis.

Results are summarized in the Table: DBP=diastolic BP, HR=heart rate, M=morning hours (07:00–13:00), N=night hours (24:00–07:00), SBP=systolic BP.

In conclusion, both agents significantly reduced arterial BP to the same extent. However, moxonidine had a favorable effect on cardiac autonomic balance during night hours, whereas nebivolol during morning hours. Thus, the effect of antihypertensive agents on cardiac autonomic balance differs greatly and the clinical significance of it needs further investigation.

Key Words: Sympathetic Inhibition, Heart Rate Variability, Antihypertensive Treatment

**OR-31**

CENTRAL VERSUS PERIPHERAL SYMPATHETIC INHIBITION ON ARTERIAL BLOOD PRESSURE AND HEART RATE VARIABILITY IN ESSENTIAL HYPERTENSION

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Key Words: Sympathetic Inhibition, Heart Rate Variability, Antihypertensive Treatment

**OR-32**

WHOLE-BLOOD VISCOITY, AUTONOMIC NERVOUS SYSTEM, AND EFFECTS OF MENTAL STRESS IN BORDERLINE HYPERHENTIC AND NORMOTENSIVE SUBJECTS

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Increased whole-blood viscosity (WBV) is related to hypertension and insulin resistance, which are associated with increased sympathetic and decreased vagal activity. We tested whether WBV increases during mental stress and relates to autonomic nervous system activity and insulin sensitivity, and compared borderline hypertensive and normotensive subjects. Twenty borderline hypertensive men, 21 normotensive men, and 10 women were studied during 90-min hyperinsulinemic glucose clamp and 7-min mental arithmetic stress test (MST). WBV (rotational rheometer) at shear rates 0.5 and 201 s⁻¹, and plasma norepinephrine (NE) were measured. Heart rate variability (HRV) was computed from continuous ECG and baroreflex sensitivity (BRS) from
finger blood pressure (BP) recordings (transfer technique). WBV correlated negatively with insulin sensitivity in men ($r = -0.40, P < 0.01$) and women ($r = -0.64, P < 0.05$). WBV increased during MST (shear rate $0.5 \text{s}^{-1}$; $17.6–18.7 \text{mPa}s$, $P < 0.01$; shear rate $201 \text{s}^{-1}$; $3.7–3.9 \text{mPa}s$, $P < 0.0001$). NE increased ($P < 0.0001$) while HRV ($P < 0.0001$) and BRS ($P < 0.001$) declined. WBV was positively related to NE and negatively to high-frequency HRV or BRS, independent of adiposity, BP group, and gender. $\Delta$WBV (shear rate $201 \text{s}^{-1}$; $\beta = 0.27$, $P < 0.05$) and $\Delta$NE ($\beta = 0.55$, $P < 0.0001$) were independently related to diastolic $\Delta$BP. During MST, WBV (both shear rates) and $\Delta$WBV (shear rate $0.5 \text{s}^{-1}$) were higher in borderline hypertensive than normotensive men (all $P < 0.05$). WBV is adversely affected by increased sympathetic activity and blunt vallar HR control. The hemodynamic effect of mental stress is increased in borderline hypertension and may contribute to the acute increase in BP. Altered autonomic nervous system function and increased WBV may be related components of the insulin resistance syndrome.

Correlation Coefficients in men ($n = 41$) between Whole Blood Viscosity and Indices of Autonomic Nervous System Activity.

<table>
<thead>
<tr>
<th>Whole Blood Viscosity</th>
<th>RR</th>
<th>LF</th>
<th>HF</th>
<th>BRS</th>
<th>NE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose Clamp</td>
<td>$-0.46*</td>
<td>-0.17</td>
<td>-0.31*</td>
<td>-0.43</td>
<td>0.44†</td>
</tr>
<tr>
<td></td>
<td>$-0.51</td>
<td>-0.36</td>
<td>-0.31*</td>
<td>-0.44</td>
<td>0.31</td>
</tr>
<tr>
<td>Mental Stress</td>
<td>$-0.46</td>
<td>-0.32*</td>
<td>-0.32*</td>
<td>-0.41</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>$-0.54</td>
<td>-0.39</td>
<td>-0.42</td>
<td>-0.31</td>
<td>0.37</td>
</tr>
</tbody>
</table>

$\text{RR}$, mean R-R interval; $\text{LF}$, low-frequency power; $\text{HF}$, high-frequency power; $\text{BRS}$, baroreflex sensitivity; $\text{NE}$, norepinephrine.

Key Words: Whole Blood Viscosity, Autonomic Nervous System, Hypertension

OR-33

HEMODYNAMIC, AUTONOMIC AND NEUROHORMONAL BEHAVIOUR IN A TEN-MINUTE HEAD-UP TILT EVALUATION IN DIFFERENT ORTHOSTATIC INTOLERANCE SYNDROMES

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Several different orthostatic intolerance (OI) syndromes are described in literature. They all share symptoms like dizziness and orthostatic syncope, however the pathophysiology is somewhat different. Our goal was to study the autonomic and hemodynamic profile in different patients with OI.

We studied in basal and during the first ten minutes of head-up tilt test (HUTT), eight patients with autonomic failure (Group A), eight patients with neurocardiogenic syncope (HUTT+ -group B) and 16 normal controls, aged matched (Group C).

Beat-by-beat BP and HR were continuously monitored and digitised at 500 Hz. The baroreceptor $\alpha$-index gain (vagal reflex - BRG), high frequency of RR variability (vagal tonus - HFRR) and low frequency of systolic pressure variability (sympathetic tone - LFSAP) were calculated. Cathelaminines were assayed by fluorometric HPLC and plasma brain and atrial natriuretic peptides were also measured. Hemodynamic data were derived and calculated by the modelflow® method.

In supine, cardiac output and systolic volume were similar in all groups. Mean arterial pressure and BNP was higher in group A, but NOR, BRG, HFRR and LFSAP were extremely low in this group. BRG and ADR were higher in group B than in controls (C). Within the first ten minutes of HUTT there was a huge drop of CO, SV and MAP in group A and maintenance of very low levels of neurohormonal and autonomic function. HR, LFSAP and ADR had a higher rise at HUTT in Group B compared with normals but a significant decrease of BRG was noted. BNP did not change with tilt in any group.

Orthostatic intolerance syndromes share similar clinical symptoms but may show important hormonal, autonomic and hemodynamic differences after passive orthostatism.

Autonomic, neuro-hormonal and hemodynamic profile in different patients with OI.

<table>
<thead>
<tr>
<th>$\Delta$/Tilt</th>
<th>$\Delta$SV (mL)</th>
<th>$\Delta$HR (bpm/hr)</th>
<th>$\Delta$MAP (mmHg/hr)</th>
<th>$\Delta$BPG (mmHg/hr)</th>
<th>$\Delta$LFSAP (mmHg/hr)</th>
<th>$\Delta$NE (pg/ml/hr)</th>
<th>$\Delta$ADR (pg/ml/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal/Q</td>
<td>$-38 \pm 21^*</td>
<td>12 \pm 8</td>
<td>-32 \pm 23</td>
<td>-0.2 \pm 0.1</td>
<td>1.1 \pm 1.1</td>
<td>29 \pm 28</td>
<td>3.5 \pm 4.2</td>
</tr>
<tr>
<td>Group B</td>
<td>$-23 \pm 12</td>
<td>22.9*</td>
<td>10 \pm 4</td>
<td>-15.4 \pm 11.3</td>
<td>15.8 \pm 8.8</td>
<td>246 \pm 260</td>
<td>62.2 \pm 42.6</td>
</tr>
<tr>
<td>Group C</td>
<td>$-22 \pm 7</td>
<td>12 \pm 8</td>
<td>15 \pm 7</td>
<td>-4.8 \pm 6.3</td>
<td>4.0 \pm 3.9</td>
<td>206 \pm 155</td>
<td>11.7 \pm 9.1</td>
</tr>
</tbody>
</table>

Data are mean ± sd; *p < 0.05 ±

Key Words: Orthostatic Intolerance, Tilt, Autonomic Nervous System

OR-34

HYPERTENSIVE ELICIT HIGHER PULSE WAVE VELOCITY AT REST AND DURING AN ISOMETRIC EXERCISE GRIP TEST

Ciaran F. Reid, Michael A. Conway. Department of Cardiology, St. Luke’s Hospital, Kilkenny, Ireland.

Background: Increased arterial stiffness or its inverse, reduced compliance, is both a cause and consequence of raised blood pressure. It is usually assessed non-invasively at rest using pulse wave velocity (PWV), which is elevated both in treated and untreated hypertension. Little is known about the PWV of the upper limb vasculature, especially among exercising hypertensives. Isometric exercise (ISOMEX) induces an acute vascular stiffness increase due to amplified sympathetic discharge, which could be expected to add to the heighten any neurogenic activation underlying hypertension. We devised an ISOMEX protocol to evaluate whether PWV would be particularly elevated in hypertensives during the grip test.

Methods: Carotid–radial PWV and non-invasive hemodynamics (BP & HR) were compared in 12 treated hypertensives (HTN) (mean SE age): 60.9 (3.8) yrs, BMI 30.0 (1.1) kg/m², 7 females) and 12 control subjects (CON) (60.0 (3.3) yrs, BMI 26.2 (1.2) kg/m², 7 females) during 3 minute supine sub-maximal ISOMEX (30 % MVC) of the non-dominant arm.

Results: Compared to rest, ISOMEX significantly elevated the PWV (table). PWV at rest was higher in HTN. The absolute HTN PWV increase during ISOMEX ($\pm 1.25$) m/s compared to CON (A 0.91 (0.2)) m/s, was greater (27.5%), but this difference was not significant ($P = 0.47$). The PWV of CON during exercise was equivalent to that at rest in HTN, ISOMEX significantly elevated all other hemodynamic parameters in both groups, consistent with previous studies.

<table>
<thead>
<tr>
<th>CON</th>
<th>HTN</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWV rest (m/sec)</td>
<td>8.21 (0.3)*</td>
</tr>
<tr>
<td>PWV exercise (m/sec)</td>
<td>9.11 (0.3)*</td>
</tr>
<tr>
<td>% Change</td>
<td>$11.4 (2.2)^b$</td>
</tr>
<tr>
<td>$\Delta$HR</td>
<td>$\Delta$MAP</td>
</tr>
<tr>
<td>$\Delta$HR</td>
<td>$\Delta$MAP</td>
</tr>
<tr>
<td>$\Delta$HR</td>
<td>$\Delta$MAP</td>
</tr>
</tbody>
</table>

Values are (mean (SE))

Conclusion: These results show that ISOMEX amplifies the PWV in CON and HTN. Whilst the response in patients is more marked, it is not significantly higher. The equivalence of resting HTN PWV and ISOMEX induced CON PWV raises question about a role for chronic inappropriate activation of the afferent and efferent limbs of the isometric reflex in the etiology of essential hypertension. However, the non-significant difference in the response between CON and HTN may suggest that hypertension is not associated with a hyperactive PWV response to the grip test.

Key Words: Hypertension, Isometric Exercise, Pulse Wave Velocity