Blood pressure variability in man: its relation to high blood pressure, age and baroreflex sensitivity

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Summary

1. Intra-arterial blood pressure and heart rate were recorded for 24 h in ambulant hospitalized patients of variable age who had normal blood pressure or essential hypertension. Mean 24 h values, standard deviations and variation coefficient were obtained as the averages of values separately analysed for 48 consecutive half-hour periods.

2. In older subjects standard deviation and variation coefficient for mean arterial pressure were greater than in younger subjects with similar pressure values, whereas standard deviation and variation coefficient for heart rate were smaller.

3. In hypertensive subjects standard deviation for mean arterial pressure was greater than in normotensive subjects of similar ages, but this was not the case for variation coefficient, which was slightly smaller in the former than in the latter group. Normotensive and hypertensive subjects showed no difference in standard deviation and variation coefficient for heart rate.

4. In both normotensive and hypertensive subjects standard deviation and even more so variation coefficient were slightly or not related to arterial baroreflex sensitivity as measured by various methods (phenylephrine, neck suction etc.).

5. It is concluded that blood pressure variability increases and heart rate variability decreases with age, but that changes in variability are not so obvious in hypertension. Also, differences in variability among subjects are only marginally explained by differences in baroreflex function.

Key words: age, baroreflexes, blood pressure variability, essential hypertension, heart rate, neck chamber, phenylephrine, trinitroglycerine.

Introduction

In the past years several studies have shown that in man blood pressure has a marked degree of variability which depends on the occurrence of well-recognized behavioural conditions (sleep, exercise, emotions etc.) (Bevan Honour & Stott, 1969; Littler, West, Honour & Sleight, 1978; Watson, Stallard & Littler, 1979) and possibly on other factors (Littler, Honour, Sleight & Stott, 1972; Millar-Craig, Bishop & Raftery, 1978). This variability is an important phenomenon to be defined both for discovering the multifold influences normally involved in human blood pressure regulation and for obtaining more precise information on the existence and the severity of a hypertensive state in a given patient (Sokolow, Wertegard, Kain & Hinman, 1966; Mancia & Zanchetti, 1980). We have asked ourselves three questions concerning blood pressure variability in man: (1) is blood pressure variability different in hypertensive subjects from that in subjects with normal blood pressure?; (2) does this variability change in relation to age?; (3) are differences in variability substantially explicable on the basis of different baroreflex sensitivities?

Methods

We studied ambulant subjects of both sexes who had either normal blood pressure or essential hypertension. No subject had major diseases (except the hypertension) and none had been given cardiovascular drugs during the preceding
3 weeks. The study was performed while the subjects were hospitalized, in an attempt to standardize their living and environmental conditions.

Arterial blood pressure was measured continuously with a catheter placed in a radial artery and an Oxford portable transducer-tape recorder apparatus. In each subject the measurement was started in the early evening and was terminated 24 h later. The blood pressure tracing was first visually scrutinized and, after determination of the good quality of the pulse wave (this was the case in all subjects considered in this study), analysed by a computer.

The analysis was carried out in a manner described in a previous report (Cioffi & Di Rienzo, 1980). Briefly, mean arterial pressure was calculated by averaging 60 values (one every 50 ms) within consecutive periods of 3 s, systolic pressure, diastolic pressure and heart rate being similarly calculated as the values occurring within these 3 s time intervals. Averages and standard deviations were calculated for each of the 48 half-hours in which the recording period was divided. The averages of the 48 different averages provided mean values for the whole 24 h period, and the averages of the 48 different standard deviations provided the measures of the variability occurring within half-hour time spans. The standard deviations were also calculated as percentages of the average 24 h values to obtain not only the variability in absolute values but also the variation coefficient, regardless of the baseline differences in the various subjects.

Arterial baroreceptor reflexes were tested by two methods. In 38 subjects, linear regressions were calculated between the rise in systolic pressure and the averages of the 48 different standard deviations were calculated for each of the 48 half-hours in which the recording period was divided. The values were greater in the hypertensive than in the normotensive group. It can also be seen that these results were not paralleled by the heart rate data. As for blood pressure, 24 h mean heart rate values were greater in the hypertensive than in the normotensive subjects. Heart rate variability,

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**Table 1. Variability of mean arterial pressure and heart rate in subjects of different ages and with normal or high blood pressure**

Results are expressed as means ± SE. Statistical analysis was performed by the Student’s t-test. Subjects belonging to the younger and older groups were selected among those having an age respectively equal to or less than 38 years and equal to or greater than 48 years. Standard deviation (for half-hour periods) in absolute values; variation coefficient: standard deviation as percentage of 24 h mean arterial pressure or heart rate value.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Arterial pressure</th>
<th>Heart rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24 h arterial pressure (mmHg)</td>
<td>sd (mmHg)</td>
</tr>
<tr>
<td>Normotensive group (n = 22)</td>
<td>38.6 ± 2.9</td>
<td>88.1 ± 1.7</td>
</tr>
<tr>
<td>Hypertensive group (n = 41)</td>
<td>44.8 ± 1.6</td>
<td>137.9 ± 3.1</td>
</tr>
<tr>
<td>P</td>
<td>&lt;0.05</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Younger group (n = 31)</td>
<td>30.2 ± 1.1</td>
<td>109.4 ± 3.6</td>
</tr>
<tr>
<td>Older group (n = 26)</td>
<td>54.6 ± 1.3</td>
<td>116.7 ± 3.9</td>
</tr>
<tr>
<td>P</td>
<td>&lt;0.001</td>
<td>N.S.</td>
</tr>
</tbody>
</table>
human, was not significantly different in the two groups when expressed either in absolute values or as variation coefficients.

Table 1 also shows the results obtained when two groups of subjects with similar 24 h blood pressures but with different ages were analysed. Blood pressure variability was significantly greater in the elderly subjects when expressed either in absolute or in percentage values. On the other hand, heart rate variability showed an opposite alteration, as both its indices were significantly less pronounced in the older than in the younger group.

Attempts to correlate blood pressure variability and baroreflex sensitivity gave only partially positive results. No correlation was found between variability indices and baroreflex sensitivity obtained by trinitroglycerine and positive neck pressure application. There was a significant inverse linear relationship between blood pressure variability expressed in absolute value and baroreflex sensitivity obtained by phenylephrine ($r = 0.49$, $P < 0.01$), but such relationship was completely lost when the variation coefficient was used instead. There was no correlation between absolute values of blood pressure variability and the baroreflex sensitivity obtained by the negative neck pressure application, although in this instance use of the variation coefficient made an inverse correlation of borderline significance to appear ($r = 0.32$, $P < 0.05$).

Discussion

Our study confirms that blood pressure variability is greater in subjects with essential hypertension than in normotensive subjects (Goldberg, Raftery, Cashman & Stott, 1978) but it also makes clear that this phenomenon is limited to the variability expressed in absolute values and is actually reversed when such value is transformed into a variation coefficient (that is, when it is expressed as percentage of the existing blood pressure). Which of the two values better represents the biological phenomenon of variability is debatable. Nevertheless, it seems to us important to underline that although absolute blood pressure values do oscillate more in hypertensive patients, their percentage oscillations around the mean are in fact similar to the percentage oscillations that can be observed in normotensive individuals.

A second point that emerges clearly from our study is that blood pressure variability shows an increase (this time both in absolute and percentage values) with age compared with heart rate variability, which shows a simultaneous clear-cut reduction. An increased blood pressure variability with age may be explained by the fact that in older people any given change in stroke volume is likely to induce a greater blood pressure change owing to their less compliant arterial walls. A reduced heart rate variability under the same circumstances may reflect a reduced responsiveness of the heart to various stimuli.

The last comment refers to the inverse relationship between blood pressure variability and arterial baroreflexes. Our data indicate that such a relationship, whenever it can be found, is of a weak order, and probably accounts for only a small portion of the differences in spontaneous pressure variability that occur in different subjects. Clearly other factors seem to be largely involved in this phenomenon, those originating in the brain centres and in the vascular smooth muscle being the most likely ones.

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References


