AGE-RELATED CIRCADIAN VARIATIONS OF CARDIAC AND RESPIRATORY COMPONENTS OF THE CAROTID BAROREFLEX IN HUMANS

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Our previous studies indicated the presence of a respiratory effector of carotid baroreceptor activation: the respiratory resistance. A brief decrease in respiratory resistance was observed in response to carotid baroreceptor activation. In the course of aging we found a decrease in the heart response to carotid baroreceptor activation and disappearance of the respiratory response. The aim of the present study was to determine whether the circadian variations of baroreflex sensitivity, as related to aging, are attributable to changes in cardiovascular and respiratory control in the elderly. We evaluated the cardiac responses and the reflex changes of the respiratory resistance to carotid baroreceptor activation every two hours in: 12 healthy male subjects aged 20-38 years, 6 male subjects aged 20-38 years and 6 male subjects aged 70-80 years. Two neck-chambers were used to produce a brief suction, applied to carotid sinus regions, activating the carotid baroreceptor. We found that the circadian courses of the cardiac and respiratory responses to baroreceptor activation were shifted down in the older groups of subjects, as compared with the younger ones. In the 50-80-year old subjects no respiratory response to carotid baroreceptor stimulation was observed. We further found that the impaired carotid baroreflex control of heart function and of respiratory resistance, observed in older subjects, reached a minimum between 3.00 and 7.00 hours in the morning. We conclude that this period is a risk time for the occurrence of cardiac disorders, especially for cardiac arrhythmias, and it is also the time of impaired reflex control of respiratory resistance.

Key words: carotid cardiac baroreflex, aging, circadian rhythmicity, respiratory resistance
INTRODUCTION

In 1971, Gribben at al (1) have shown a progressive decrease in baroreflex sensitivity associated with advancing age along with rising systolic blood pressure. The age-related decrease in the baroreceptor sensitivity is believed to contribute to orthostatic hypotension and related problems of dizziness (2). Postural hypotension (occurs in approximately 30% of the population aged 65 or more), which is caused in part by autonomic dysregulation in the elderly, plays a major role in the risk of falling. Reduced baroreceptor sensitivity is also associated with higher mortality from arrhythmias following myocardial infarction (3). Over the past 20 years, an unequivocal circadian periodicity pattern has been established in cardiovascular diseases (4, 5, 6). The aim of the present study was to determine whether the circadian variations of baroreflex sensitivity as a function of human aging are attributable to changes in the cardiovascular control in the elderly.

Our previous studies showed that carotid baroreflex activation produces a brief decrease in airway resistance (7, 8). Such a respiratory response disappeared in the older healthy subjects (8). Another aim of the present study was to investigate the circadian rhythmicity of the respiratory component of baroreflex.

MATERIAL AND METHODS

Three groups of healthy subjects, as shown in Table 1, were involved in the study. All subjects were screened for cardiovascular, hypertensive and respiratory disorders, and all were physically active. The study protocol was accepted by the Ethics Committee of Bydgoszcz Medical University; permit No. KB/252/2002.

**Activation of carotid baroreceptor**

In order to activate carotid baroreceptors two separate small neck capsules were used (9). Each capsule was placed on the neck over the carotid bifurcation. The carotid baroreceptor activation was evoked by applying a negative pressure (-40 mmHg), 250 ms after the R-wave during the expiratory phase of breathing. The maximal rate of air pressure drop at the neck was 400 mmHg/s.

The following variables were recorded continuously: R-R intervals, measured from ECG with a resolution of 1 ms, the respiratory phase and rate of breathing, measured with a thermistor.

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<th>Table 1. Groups of subjects involved in the study.</th>
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Sys BP- systolic blood pressure, Dias BP- diastolic blood pressure.
placed at a nose orifice, and air pressure in the neck capsules. An average R-R interval was calculated from 10 s of recording preceding the onset of stimulus and is referred to as the baseline. The cardiac baroreflex response was expressed as the gain of the heart response (GHR), calculated as R-R prolongation compared with the baseline level divided by the neck pressure change.

**Measurement of respiratory resistance**

The oscillatory method (Siregnost FD5, Siemens) was used to measure continuously airway resistance, as described in detail elsewhere (7, 10). Briefly, the principle of this method is based on spontaneous ventilation through a mouthpiece connected to a constant comparative resistance. The pump generating oscillatory airflow was connected into the mouthpiece. Airway pressure was measured continuously, whereas respiratory (airway) resistance was calculated. Subjects stayed in the laboratory for 24 h. All measurements were performed every two hours in the standard conditions: constant climate and continuous bed rest for 24 h, low protein diet. The Student's t-test was used for statistical evaluations.

**RESULTS AND DISCUSSION**

In all age groups, GHR showed a circadian rhythmicity with a maximum between 19.00 and 23.00 hours and a minimum between 3.00 and 7.00 hours (Fig. 1). The circadian courses of GHR were shifted down in the older groups, as compared with the younger subjects. Differences between the younger group and both older groups (I and II) were significant in all daily courses (P<0.05).

A brief decrease in respiratory resistance in response to carotid baroreceptor activation was observed only in the younger group. Circadian rhythmicity of this response showed a minimum between 3.00 and 7.00 hours and a maximum between 19.00 and 23.00 hours (Fig. 2). In both older groups (I and II) no respiratory response to carotid baroreceptor stimulation was observed.

![Fig. 1. Gain of the heart response (GHR) to carotid baroreceptor activation during a daily course in a group of younger and two groups of older subjects.](image-url)
The present study showed the age-related decrease in carotid baroreceptor cardiac reflex and the age-related disappearance of the respiratory component of baroreflex. In 2000, O'Mahony et al (11) have shown that the decrease in baroreflex sensitivity is not associated with reduced efferent vagally or sympathetically mediated cardiovascular responses to physical or cognitive stress. They support the theory that "the age-related decline in baroreflex sensitivity is a result of increased arterial stiffness". The process of biological aging decreases the baroreflex gain (12, 13) and increases vascular stiffness (14, 15). Hunt et al (16) have suggested that "deficits in both the mechanical and neural components of baroreflex contribute to the lower integrated cardiovagal gain". Aging seems to be associated with significantly increased muscle nerve sympathetic activity (17, 18, 19). Yamada et al (19) have suggested that this phenomenon also results from impairment of arterial baroreceptors or from reduced arterial wall compliance. As a consequence: the decrease in afferent baroreflex neural activity leads to "gradually increased baroreflex sympathetic outflow, manifested as increased muscle nerve sympathetic activity at rest" (11).

The impaired cardiac response to carotid baroreceptor activation, mediated through the vagal nerve, means the impaired vagal control of the heart function in the elderly, and thus the greater probability of the occurrence of cardiac arrhythmias. The time of the special impendency is the same for the younger and older subjects: between 3.00 and 7.00 hours. The extremely reduced GHR during this time in older subjects means the lack of the vagal control of heart function.

The influence of aging seems not only related to the cardiac response to baroreceptor activation, but also to the respiratory component of baroreflex. In men aged 20-40 years, carotid baroreceptors may influence airway resistance, resulting in a decrease in inspiratory effort: decreases in the activities of the diaphragm and chest wall inspiratory muscles (8). Disappearance of the
respiratory component of baroreflex in the course of aging (in subjects 40 years or older) or its physiological reduction between 3.00 and 7.00 hours in younger subjects might evoke an imbalance between the activities of the upper airway and diaphragm and chest wall inspiratory muscle groups, which may facilitate collapse of the upper airway.

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REFERENCES


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