Cerebral Hemodynamic Changes at Basilar Artery in Obstructive Sleep Apnea Syndrome after Continuous Positive Airway Pressure Treatment

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Background: Cerebral vasoreactivity in obstructive sleep apnea syndrome is altered. Continuous positive airway pressure is effective in the reduction of the occurrence of apneas. We studied whether this treatment also improves cerebral vasoreactivity. *Methods:* The breath-holding maneuver was performed and assessed by apnea test with transcranial Doppler in the basilar artery. After 2 years of continuous positive airway pressure treatment, the test was repeated. *Results:* There is an improvement in the apnea test after continuous positive airway pressure. There are increases in the pulsatility index, diastolic blood pressure, and basal heart rate. The improvement in the apnea test depends on the body mass index of the patient. *Conclusions:* Cerebral vasoreactivity as measured by the apnea test improves after 2 years of continuous positive airway pressure. This improvement depends of the body mass index of the patient. **Key Words:** Basilar artery—cerebral hemodynamics—continuous positive airway pressure—obstructive sleep apnea syndrome—transcranial Doppler.

Obstructive sleep apnea syndrome (OSAS) is a common disorder with a prevalence of approximately 4% in middle-aged men and 2% in middle-aged women.[1] OSAS is characterized by the recurrent collapse of the upper airway during sleep, resulting in repetitive episodes of asphyxia and arousal from sleep. This fragmentation of sleep results in daytime sleepiness, a decreased quality of life, and increased risk of injuries from motor vehicle crashes and industrial accidents.[2] Although an increased prevalence of OSAS in patients with acute stroke has been known for several years,[3] recent prospective observational studies have shown that OSAS increases the risk of stroke independently of other known risk factors.[4]

With regard to a pathophysiologic link between OSAS and stroke, evidence suggests that OSAS is associated with multiple causal factors of endothelial damage and atherosclerosis, such as arterial hypertension,[5] systemic inflammation,[6] and coagulation factors.[7] Changes in cerebral blood flow have been described in patients with OSAS.[8] Continuous positive airway pressure (CPAP) is effective in reducing symptoms of sleepiness and improving quality of live in people with moderate and severe OSAS.[9] CPAP treatment in OSAS patients prevents new vascular events after an ischemic stroke[10] and reduces blood pressure (BP).[11]

Cerebral autoregulation is a mechanism that allows cerebral blood vessels to maintain a constant cerebral blood flow over a wide range of cerebral perfusion pressure. Cerebral circulation is also profoundly affected by change in $Paco_2$, and co_2 reactivity defines the changes in cerebral blood flow in response to changes in $Paco_2$.[12]

Transcranial Doppler (TCD) is a noninvasive method suited for cerebral hemodynamic studies. Rapid alterations in the cerebral blood flow velocity (CBFV) may be detected

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easily. Changes in blood flow, measured with electromagnetic and Xenon techniques, correlate well with changes in Doppler flow velocity.[13] The Doppler technique better suits the purpose of the present study.

The aim of our study was to evaluate cerebrovascular reactivity in the basilar artery (BA) during wakefulness in patients with OSAS and to estimate the effect of treatment with CPAP on cerebral hemodynamics.

Methods

Patients

This prospective study included consecutive patients between March 2009 and November 2009 who were evaluated in the Sleep Laboratory at Albacete University Hospital and who were found to have symptoms suggestive of OSAS. Exclusion criteria were as follows: cardiopulmonary illnesses, previous cerebrovascular disease, extracranial carotid stenosis or occlusion, intracranial artery stenosis, lack of a temporal bone acoustic window, and treatment with beta-blockers. All patients were ≥18 years of age. The study protocol was reviewed and approved by the ethics committee of our hospital, and all subjects provided written, informed consent to participate in the study.

Major vascular risk factor (hypertension, smoking, hyperlipidemia, and diabetes mellitus), body mass index (BMI), and Epworth sleepiness scale (ESS) were recorded. Hypertension was defined ≥1 of for following: resting systolic BP of at least 140 mm Hg, resting diastolic pressure of at least 90 mm Hg, or treatment with antihypertensive medications.

Polysomnography

Full-night attended polysomnography was obtained using a 16-channel polygraph (SleepLab 1000P; Aequiton Medical Inc, Minneapolis, MN), including 3 electroencephalographic channels (C4-A1, Cz-O2, and C3-A2), 2 electro-oculogram channels, submental electromyogram (EMG), and tibialis anterior EMG of both legs. Respiration was monitored using chest and abdominal respiratory belts and nasal oral airflow. Oxygen saturation was determined by means of a pulse oximeter.

Apnea was defined as a complete cessation of airflow for ≥10 seconds, and hypopnea was defined as a reduction of ≥30% in airflow for 10 seconds associated with ≥4% desaturation. The apnea–hypopnea index (AHI) was the sum of the number of apneas and hypopneas per hour of sleep. The percentage of visually scored total sleep time spent with an oxygen saturation <90% (T90) was obtained. OSAS was confirmed by polysomnography, using the threshold of AHI ≥10.

Assessment of Cerebrovascular Reactivity

All subjects underwent cervical and TCD ultrasonography (Multi-DOP B+; DWL Elecktronische Systeme, Singen, Germany), which excluded extra- and intracranial vessel stenosis. Patients were instructed not to smoke or drink caffeinated or alcoholic beverages for 24 hours before their assessment. The study was carried out in a quiet room with subjects lying in the supine position without any visual or auditory stimulation.

The breath-holding maneuver was performed according to the simplified test of cerebral perfusion reserve of Ratnatunga and Adiseshiah.[14] After normal breathing of room air, the patients were instructed to hold their breath after a normal inspiration. During the maneuver, the mean blood velocity was recorded continuously. The Apnea Test (ApT) was calculated as the increase of mean artery velocity during the apnea and was expressed as a percentage using the following formula:

$$[(\text{Artery velocity in apnea}) - (\text{Resting artery velocity})]/\text{Resting artery velocity}$$

Subjects were asked to hold their breath for at least 30 seconds. The spectrum of the involved curve by TCD were registred in the basilar at a depth of 80 mm.

The pulsatility index (PI) according to Gosling et al[15] was automatically calculated by TCD as an indirect measure for vascular resistance. Mean blood pressure (BP) and heart rate (HR) were continuously monitored by means of a BP monitor (BCI 3100; BCI International, Waukesha, WI), and values at both rest and apnea were obtained.

ApT, ESS, and BMI were repeated after 2 years of CPAP treatment. The optimal pressure of CPAP was estimated by the predicted formula of Miljeteig and Hoffstein.[16]

Statistical Analysis

Statistical analysis was performed using SPSS statistical software (version 15.0; SPSS Inc, Chicago, IL). The normality of data distribution was assessed. Continuous data were expressed as mean ± standard deviation (SD). $P < .05$ was considered to be statistically significant. The variation between pre- and post-CPAP values of the variables was measured as the percentage of change over the pre-CPAP values. Our hypothesis was that CPAP treatment during 2 years in OSAS leads to at least a 25% improvement in baseline values of ApT.

Comparisons between pre- and post-CPAP values of cerebral hemodynamics parameters were made with the Student *t* test or the Wilcoxon test for variables without