INTRODUCTION

Sleep disordered breathing (SDB) is a frequent finding in the elderly. SDB is related to morbidity, mortality, quality of life, disability, and cognitive impairment. Treatment of choice for SDB is nasal positive airway pressure breathing (nCPAP). The impact of treatment for SDB on activities of daily living (ADLs) is unclear. We therefore investigated the relationship between SDB and ADLs in a sample of elderly in-hospital patients with severe SDB defined as an oxygen desaturation index of 30 events per hour. All patients eligible were assigned to nCPAP therapy. Patients with refusal of nCPAP were offered nocturnal oxygen supply via nasal prongs. The Barthel-index (BI) at admission and discharge was used to measure ADLs. Two hundred patients with a mean age of 81±7 years were included. 22 (11%) patients accepted nCPAP therapy, 42 (21%) patients accepted oxygen therapy and 136 (68%) patients refused both treatment options. The subgroups did not differ significantly in BI at admission and length of stay in hospital. BI increased from 42±28 to 49±30 in patients with refusal of any treatment, from 39±23 to 61±20 in patients with oxygen therapy and from 48±35 to 72±28 in patients with nCPAP therapy. The BI at discharge differed significantly between all three patient groups (p<0.03). Logistic regression analysis revealed that Barthel Index at admission and treatment with nCPAP or treatment with oxygen were independently associated with a gain in BI of at least 30 points. Age, dementia or length of in-hospital stay showed no association with gain in BI. This is the first study that shows an impact of treatment for severe SDB on ADLs in elderly patients. Furthermore, treatment with nCPAP and oxygen supply nearly had the same impact on ADLs. Since the higher rate of acceptance of oxygen therapy and the important impact of oxygen supply on BI, administration of oxygen seems to be a rational alternative in elderly subjects with severe sleep apnea and refusal of nCPAP.

Key words: activities of daily living, nasal continuous positive airway pressure, oxygen supply, sleep disordered breathing, elderly

MATERIAL AND METHODS

Sample

The study protocols and informed-consent documents were approved by an institutional Review Board. Subjects were
recruited from an ongoing study conducted to investigate the implications of SDB in elderly in-hospital patients. Subjects were eligible if they were in a stable health condition, gave informed consent, and suffered from severe SDB defined as an ODI of at least 30 oxygen drop-events per hour.

**Age, diagnoses and co-morbidities, geriatric assessment**

Data on gender, age, educational status, comorbidities, and geriatric assessment were used. Living conditions were classified as living in a family, living alone without relatives, and living in a nursing home. The following comorbidities were registered: arterial hypertension, congestive heart failure, history of stroke, dementia, diabetes mellitus, atrial fibrillation, and chronic obstructive pulmonary disease. Geriatric assessment encompassed the measurement of the activities of daily living (ADLs) by means of Barthel index (19). The BI measures independence in activities of daily living (ADLs) and has been used frequently in research concerning older subjects. The score ranges from 0 to 100. The ten ADLs assessed are bowel control, bladder control, personal hygiene, toilet transfer, bathtub transfer, feeding, dressing, wheelchair transfer to and from the bed, walking, and ascending and descending stairs. BI measurement was realized at admission and at discharge by nurses blinded to the aim of this study. A substantial improvement of BI was defined as an increase of ≥1 SD of that at admission. Dementia was diagnosed according to established criteria (20). Severity of dementia was assessed by the Mini Mental Status (MMSE), a widely used tool. The range encompasses 0 to 30 points, with a cut-off value of 24 or less defining cognitive impairment (21).

**Measurement of sleep disordered breathing**

Patients were screened using a pulse oximeter (SOMNOcheck, Fa. Weinmann, Hamburg, Germany). Sensory probes of the pulse oximeter were attached to the index finger. Probes which were detached accidentally during the night were replaced as soon as possible by a nurse. The mean oxygen saturation during the first five minutes after probe placement was taken as a baseline awake saturation. Oximetry results between 22:00 and 6:00 were defined as nocturnal readings. It was assumed that most patients would have been asleep during this time. Desaturations were defined as a 4% fall in saturation from baseline and were reported per hour of registration as ODI. Only recordings with a registration time of at least six hours were accepted. Further evaluation in a sleep laboratory was offered to all patients. Treatment options for SDB were explained and offered to all subjects and their relatives. Patients with refusal of nasal continuous positive pressure (nCPAP) therapy were offered nocturnal oxygen supply as an alternative to remove intermittent hypoxemia.

**Statistical methods**

Variables were checked regarding assumptions underlying the use of parametric and non-parametric statistics, and analyzed accordingly. Results are given as percentages for discrete data and as means±SD for continuous data as well as means±SD for continuous approximately normally distributed data. Statistical analysis is by chi square test for categorical data, and t-tests and Mann Whitney U-test for approximately normally distributed data, respectively. Paired t-tests were used for comparing paired observations within individuals, between group analyses were performed using independent group t-tests. For simultaneous evaluation of more than two variables multiple logistic regression analysis with forward stepwise inclusion was used. For comparing frequencies, odds ratios (OR) with 95% confidence intervals (CI 95%) were calculated. The α-level of significance was set at 0.05 (two-tailed). Analyses were performed using SPSS version 12.0 statistical software (SPSS Inc., Chicago, IL, USA).

**RESULTS**

Two hundred twenty seven patients with an oxygen desaturation index of at least 30 desaturation drops per hour were eligible for the study. Two hundred patients gave informed consent and were included. All patients were in a stable health condition. The sample comprised 77 men of the mean age of 80±7 years and 123 women of the mean age of 82±6 years (P<0.01). The Barthel index, as a measure of activities of daily living, increased from 43±29 at admission to 55±29 at discharge (P<0.01) during the mean hospital stay of 24±19 days. Barthel indices and length of stay did not differ according to gender.

Treatment options for SDB were explained to all the patients and their relatives. Twenty two (11%) individuals accepted nasal continuous positive pressure (nCPAP) therapy. Forty two (21%) patients with refusal of nCPAP accepted nocturnal oxygen supply via nasal cannula. The remaining one hundred thirty six patients were realized at treatment for SDB. Ninety nine subjects could be studied in the sleep laboratory successfully. This subgroup with polysomnography encompassed all 64 subjects with acceptance of treatment for SDB. Of the 136 subjects who refused treatment for SDB, 35 could also be evaluated in the sleep laboratory. All the subjects with successful polysomnography showed obstructive or mixed sleep apnea (data not shown). One hundred and one subjects refused further evaluation in the sleep laboratory for different reasons (n=82) or had insufficient data due to artefacts or absence of sleep (n=17).

*Table 1* shows the basic data of the sample regarding the type of treatment for sleep apnea. The subgroups did not differ according to the Barthel index at admission and the length of in-hospital stay. However, the subjects with acceptance of nCPAP were significantly younger. Furthermore, the subjects with acceptance of treatment for SDB with both nCPAP or oxygen

(Fig. 1. Box plot of Barthel index (BI) at admission and discharge. The sample is divided into three subgroups according to type of treatment that was accepted. BI at admission did not differ significantly between subgroups. All subgroups improved in BI (P<0.03). However, comparison of BI at discharge revealed significant between-group differences.)
were significantly less demented and had a greater improvement in the Barthel-index at discharge.

As expected, there was a high rate of co-morbidities in the sample. Data are shown in Table 2. Subsamples are given according to the type of treatment for sleep apnea. There were no significant differences in the frequency of co-morbidities between the subgroups except for dementia.

BI increased by at least 30 points, which is equivalent to one standard deviation of the Barthel index at admission, in 10 (7%) of the 136 patients with refusal of treatment for SDB, in 14 (33%) of the 42 patients with oxygen supply, and in 8 (36%) of the 22 patients with nCPAP therapy (P<0.01). An increase of at least 30 points in BI did not differ significantly between the patients with nCPAP therapy and oxygen supply.

Multiple logistic regression analysis was performed to assess the influence of oxygen supply on the BI at discharge. Patients without treatment and patients with oxygen supply were included, since these two groups were of comparable age. We chose an increase in BI of at least 30 points as the dependent variable and age, prevalent dementia, length of hospital stay, and BI at admission and treatment with oxygen as independent variables. Results are given in Table 3. BI at admission had a small influence. The greatest improvement was found for treatment with oxygen.

Table 1. Basic data of the sample, distinguishing between subgroups according to the type of treatment for sleep apnea. BI – Barthel index.

<table>
<thead>
<tr>
<th></th>
<th>Refusal</th>
<th>Oxygen</th>
<th>nCPAP</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>82 ±6</td>
<td>82 ±6</td>
<td>74 ±6</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Length of stay in hospital (d)</td>
<td>25 ±19</td>
<td>27 ±25</td>
<td>19 ±12</td>
<td>n. s.</td>
</tr>
<tr>
<td>BI at admission (0-100)</td>
<td>42 ±28</td>
<td>39 ±23</td>
<td>48 ±35</td>
<td>n. s.</td>
</tr>
<tr>
<td>BI at discharge (0-100)</td>
<td>49 ±30</td>
<td>61 ±20</td>
<td>72 ±28</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Mini Mental Status (0-30)</td>
<td>18 ±8</td>
<td>25 ±5</td>
<td>27 ±3</td>
<td>&lt; 0.005</td>
</tr>
</tbody>
</table>

Table 2. Distribution of several co-morbid conditions regarding the type of treatment for SDB.

<table>
<thead>
<tr>
<th>CO-MORBIDITIES</th>
<th>Refusal</th>
<th>Oxygen</th>
<th>nCPAP</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>45 / 33</td>
<td>13 / 31</td>
<td>12 / 54</td>
<td>n. s.</td>
</tr>
<tr>
<td>Dementia</td>
<td>32 / 24</td>
<td>2 / 5</td>
<td>0 / 0</td>
<td>&lt; 0.002</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>20 / 15</td>
<td>7 / 17</td>
<td>3 / 14</td>
<td>n. s.</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>67 / 49</td>
<td>18 / 42</td>
<td>10 / 45</td>
<td>n. s.</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>34 / 25</td>
<td>27 / 64</td>
<td>2 / 9</td>
<td>n. s.</td>
</tr>
<tr>
<td>Obstructive pulmonary disease</td>
<td>17 / 13</td>
<td>6 / 14</td>
<td>3 / 14</td>
<td>n. s.</td>
</tr>
<tr>
<td>History of stroke</td>
<td>40 / 29</td>
<td>11 / 26</td>
<td>2 / 9</td>
<td>n. s.</td>
</tr>
<tr>
<td>History of myocardial infarction</td>
<td>30 / 22</td>
<td>6 / 14</td>
<td>4 / 18</td>
<td>n. s.</td>
</tr>
</tbody>
</table>

Table 3. Gain in Barthel Index (BI) of at least one standard deviation – equivalent to 30 points – of the BI at admission and several variables. Only BI at admission and treatment with oxygen had an independent and significant influence.

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>Wald</th>
<th>OR</th>
<th>CI 95%</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.01</td>
<td>0.03</td>
<td>0.8</td>
<td>1.0</td>
<td>(0.95–1.06)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Dementia</td>
<td>0.48</td>
<td>0.40</td>
<td>1.5</td>
<td>1.6</td>
<td>(0.7–3.5)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Length of stay</td>
<td>0.04</td>
<td>0.01</td>
<td>0.07</td>
<td>1.6</td>
<td>(0.7–3.5)</td>
<td>n.s.</td>
</tr>
<tr>
<td>BI at admission</td>
<td>0.2</td>
<td>0.1</td>
<td>5.2</td>
<td>0.98</td>
<td>(0.97–0.99)</td>
<td>0.03</td>
</tr>
<tr>
<td>Treatment with Oxygen</td>
<td>1.6</td>
<td>0.4</td>
<td>16.2</td>
<td>4.9</td>
<td>(2.3–10.7)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.7</td>
<td>2.4</td>
<td>0.05</td>
<td>1.0</td>
<td>--</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

DISCUSSION

To the author’s knowledge, this is the first report estimating the impact of treatment for sleep disordered breathing (SDB) on activities of daily living (ADLs) in a sample of elderly in-hospital patients. The results suggest that treatment for SDB causes an important gain in ADLs. A second finding is that treatment with nocturnal positive airway pressure and nocturnal oxygen supply are both effective according to improvement in ADLs.

The subjects investigated in the present study represent a typical heterogeneous sample of geriatric patients usually encountered in geriatric wards. Therefore, the results of our study can be transferred to a large and growing number of elderly in-hospital patients. One of the hallmarks of geriatrics is the preservation and restitution of the activities of daily living, the ability for self-care and independence (22). Our results demonstrate that SDB and especially intermittent hypoxemia is a modifiable risk factor for disability. Therefore, SDB has to be demonstrated that SDB and especially intermittent hypoxemia is a modifiable risk factor for disability. Therefore, SDB has to be considered by physicians caring for elderly patients. Missing the diagnosis of severe SDB may preclude affected patients from substantial success during geriatric rehabilitation. This assumption is supported by a small gain in Barthel index found in the subjects without acceptance of any treatment for SDB.

Continuous positive airway pressure therapy

Nasal positive airway pressure (nCPAP) breathing via a face mask is the treatment of choice for SDB (8). About 10% of the patients of our sample accepted nCPAP-therapy. Subjects with
nCPAP acceptance were significantly younger and had no or only mild cognitive impairments. This observation is in concordance with other studies considering nCPAP therapy in older subjects (8). For example, in a small study considering the effectiveness of nCPAP in mild-to-moderate demented patients with SDB all 39 subjects that were included accepted the device. The patients in that study were carefully selected and almost 50% of the subjects initially screened did not meet inclusion criteria (23). In another study concerning adherence to nCPAP in older subjects, those patients with adherence were significantly younger (the mean age 72±1 years) and without affected cognition (24).

NCPAP therapy for SDB is an effective treatment option in the elderly. But, only a minority of older patients will accept this treatment. Published rates of nCPAP-acceptance in the elderly usually suffer from selection bias and are not representative for the general elderly population. There is a need for a tool that reliably allows the prediction of treatment acceptance in geriatric patients.

Oxygen supply for treatment of sleep disordered breathing

Intermittent hypoxemia (IH) is one serious consequence of SDB (25). IH is independently associated with visuo-constructional abilities, mental speed, and mental flexibility (17). Furthermore, IH is inversely related to ADLs showing a dose response relationship in elderly individuals (15, 26). In a study conducted in subjects with recent stroke, those with intermittent hypoxemia defined as a oxygen desaturation index of at least 10 events per hour had a poorer gain in Barthel index. That difference was significant and persisted during a follow-up of one year (26). Therefore, it is reasonable to remove IH as an alternative therapeutic option for SDB. Some studies have investigated the influence of oxygen supply on SDB (27-29). Administration of oxygen proved partially effective removing nocturnal hypoxemia, without reversing obstruction, frequency of apneas, and arousals (27). Of note, apnea length may increase (27-29), but the prolongation was found to be mild and CO₂ retention was not encountered provided the subjects had no obstructive pulmonary disease (28). It is unclear how oxygen supply works in subjects with SDB. One mechanism might be an amelioration of cognitive function. One prospective and randomized study conducted in stroke survivors with SDB found a significant improvement of several cognitive functions (30), and cognition and ADLs are closely correlated (31). Additional studies are needed to further clarify this relationship. The results of our study are promising.

Subjects with refusal of treatment for sleep disordered breathing

The majority of the sample refused any treatment for SDB. These subjects were significantly older and were more impaired cognitively. Most of this sample met exclusion criteria used in studies concerning treatment for SDB in the elderly (23). The improvement in ADLs in this subsample of untreated SDB patients was significantly smaller compared with patients treated for SDB. It is a challenge for future research to develop and validate treatment options for SDB in elderly subjects with refusal of conventional therapy. This treatment should be adapted to the individual wishes of the elderly patient. The impact SDB has on ADLs and cognition warrants such an approach.

One major limitation of our study is a non-randomized design. A randomized design is necessary to fulfill the requirements for evidence-based medicine (32). However, such a study design precludes some subjects from a treatment that is effective. Such an approach is problematic for ethical reasons. Therefore, we applied multiple logistic regression analysis to find independent factors, with an influence on ADLs. This analysis shows that treatment with oxygen is an independent factor having a significant influence on ADLs. Furthermore, we selected only in-hospital patients with severe SDB. The effectiveness of treatment for SDB regarding ADLs in subjects with mild or moderate SDB, or community dwelling subjects, needs to be investigated in further studies.

In conclusion, our study demonstrates that oxygen supply is associated with a significant and substantial increase in Barthel index. This finding extends the knowledge about treatment for SDB in the elderly, suggesting that oxygen supply is an effective treatment option in elderly subjects suffering from severe SDB who refuse nCPAP. Substantial increases in the relative and absolute numbers of older persons in society pose a challenge for medicine. Successful aging is multidimensional, encompassing the avoidance of disease and disability, the maintenance of high physical and cognitive function, and sustained engagement in social and productive activities. SDB and intermittent hypoxemia might be a factor predictive of success in these critical domains, if recognized and treated (33). The stage is set for further intervention studies to enhance the proportion of our population aging successfully.

Conflict of interests: None declared.

REFERENCES


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