Resolvement of respiratory failure and polycythemia after CPAP treatment in a middle-aged male with severe obstructive sleep apnea

Abstract
We present the case of a 52 year-old obese (BMI = 46.2 kg/m²) man with severe obstructive sleep apnea (RDI of 60). Before CPAP treatment was applied, the patient was diagnosed with complete respiratory failure and polycythemia. During effective autoCPAP treatment (after 10 days AHI was 5.5 at 10 mbar pressure) we observed normalization of arterial blood gases (PaCO₂ of borderline value). After one month’s treatment with autoCPAP at home, we found normalization of blood morphology parameters and PaCO₂ had returned to normal, and the patient was properly oxygenated. The patient lost 22 kg during therapy (9 kg in hospital, and 13 kg at home) which resulted in the spirometric measurements returning to their normal value.

Key words: obstructive sleep apnea, respiratory failure, polycythemia, CPAP

Introduction
The main characteristics of obstructive sleep apnea (OSA) are frequently recurring episodes of stopped or seriously limited air flow through the respiratory system during sleep, usually accompanied by blood oxygen deficiency. In patients with OSA with concomitant chronic pulmonary diseases (most commonly chronic obstructive pulmonary disease [COPD]) (overlap syndrome) or giant obesity, serious perturbations of respiration occur while asleep.

In some patients with overlap syndrome or significant obesity, respiration is also irregular while awake, indicated by hypoxemia or hypoxemia and hypercapnia during the daytime [1, 2]. Verin et al. [3] diagnosed hypoxemia and hypercapnia during the daytime in a small percentage of patients with OSA with regular respiratory system activity [3].

The description of the case presented below is particularly important in view of the occurrence of complete respiratory failure and polycythemia in a patient without concomitant respiratory system diseases.

Case description
In December 2008, a 52 year-old man suffering from obesity (weight 149.8 kg, height 180 cm, BMI 46.2 kg/m²) was admitted to the Department of Respiratory Medicine of the Institute of Tuberculosis and Pulmonary Diseases in Warsaw, with suspicion of obstructive sleep apnea. A serious form of OSA was confirmed through polygraphic examination (Polymesam, MAP, Martinsried, Germany). The rate of breathing perturbations during sleep was 60/h, and the desaturation index (the ODI) was 66/h. The mean blood oxygen saturation
The arterial blood gas examination showed features of respiratory failure (PaO₂: 37.5–48.2 mm Hg, PaCO₂: 51.1–62.7 mm Hg, pH: 7.36–7.40). From the third day after beginning autoCPAP treatment, the arterial blood gases improved (PaO₂: 54–66.5 mm Hg, PaCO₂: 49.1–45.2 mm Hg). Detailed results of the arterial blood gases’ examination are presented in Table 1.

The morphology showed polyclonulia: erythrocytes 5.24 G/l, Hgb: 19.41 g/dL, Hct: 58.11%. Throughout the patient’s two week stay in the clinic, no significant improvement of the hematological parameters was seen (erythrocytes: 5.16 G/L, Hgb: 18.51 g/dL, Hct: 55.01%).

The spirometry showed a proportional (probably related to obesity) reduction of FVC and FEV1 (FVC: 3.01 L, 64% of norm, FEV1: 2.42 L, 65% of norm, FEV1/FVC was 80.31%) (therefore we suspected a restriction).

The chemical control of breathing tests showed regular respiratory response in the hypercapnic test and practically indeterminable responses in the hypoxemic test.

Table 1. Results of arterial blood gases measurement during hospitalization

<table>
<thead>
<tr>
<th>Date</th>
<th>pH</th>
<th>PaCO₂ [mm Hg]</th>
<th>PaO₂ [mm Hg]</th>
<th>HCO₃ [mmol/l]</th>
<th>BE [mmol/l]</th>
<th>SaO₂ [%]</th>
<th>ct O₂ [Vol%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008.12.03</td>
<td>7.401</td>
<td>51.1</td>
<td>48.2</td>
<td>31</td>
<td>6.2</td>
<td>83.4</td>
<td>32.6</td>
</tr>
<tr>
<td>2008.12.05</td>
<td>7.358</td>
<td>62.7</td>
<td>37.5</td>
<td>34.4</td>
<td>8.9</td>
<td>67.4</td>
<td>36.4</td>
</tr>
<tr>
<td>2008.12.05</td>
<td>7.399</td>
<td>52.9</td>
<td>48.1</td>
<td>32</td>
<td>7.2</td>
<td>83.2</td>
<td>33.6</td>
</tr>
<tr>
<td>2008.12.06</td>
<td>7.443</td>
<td>45.6</td>
<td>56.7</td>
<td>30.5</td>
<td>6.4</td>
<td>90.4</td>
<td>31.9</td>
</tr>
<tr>
<td>2008.12.07</td>
<td>7.436</td>
<td>44.4</td>
<td>54</td>
<td>29.2</td>
<td>5</td>
<td>88.9</td>
<td>30.6</td>
</tr>
<tr>
<td>2008.12.09</td>
<td>7.382</td>
<td>49.1</td>
<td>60.5</td>
<td>28.5</td>
<td>3.4</td>
<td>90.6</td>
<td>30</td>
</tr>
<tr>
<td>2008.12.12</td>
<td>7.385</td>
<td>45.5</td>
<td>61.3</td>
<td>26.6</td>
<td>1.6</td>
<td>91.1</td>
<td>28</td>
</tr>
<tr>
<td>2008.12.15</td>
<td>7.386</td>
<td>45.2</td>
<td>66.5</td>
<td>26.5</td>
<td>1.5</td>
<td>92.9</td>
<td>27.9</td>
</tr>
</tbody>
</table>

(SaO₂ avg.) was at 86%, the lowest blood oxygen saturation registered during the examination was 58% (SaO₂ min.) The patient spent 61% of sleep time in oxygen deficiency, when SaO₂ was lower than 90% (T90). The patient spent 24% of sleep time in deep oxygen deficiency (SaO₂ < 80% — T80).

The mean duration of the apnea period was 32 ± 13 seconds, the hypopnea was 27 ± 17 seconds (the longest episodes lasting 77 and 115 seconds for the apnea and hypopnea, respectively).

The symptoms had persisted for 10 years and had been aggravated in the previous 2–3 years, after the patient gained another 30 kg. The patient’s family observed numerous episodes of apnea and loud snoring during sleep. He urinated 3–4 times per night, at times waking up due to dryness of the throat. In the morning, the patient woke up sleepy. Throughout the day, the sleepiness and tiredness would intensify to such a degree that the patient would fall asleep at work. The degree of the patient’s sleepiness on the Epworth scale was 18 (the norm ≤ 9 points).

For the last 30 years, the patient had been treated for arterial hypertension (ineffective during the last year). In 2006, over the course of six months, an alloplasty of both hip joints was performed. Six months before hospitalization the patient was diagnosed with polyclonulia. The patient had been smoking cigarettes for the last 20 years (on average 20 cigarettes per day).

The general condition of the patient when admitted to the clinic was pretty good. In the physical examination centripetal obesity (neck circumference of 52 cm) and cyanosis were diagnosed. The blood pressure was high and amounted to 180/110 mm Hg. In addition, numerous trophic lesions or changes were observed along with slight swelling of the legs. No other abnormalities were diagnosed in the physical examination.

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The radiological chest examination showed platelets of atelectasis in the lower field of the right lung. The outline of the hilus was not widened and the profile of the heart of borderline size. Also, degenerative changes were diagnosed in the thoracic segment of the spine.

In the ECG examination, the heart rhythm was regular: 77/min with negative T waves in the V1–V4 leads (overload changes). After two weeks in the clinic, the changes in the V1–V4 waves had become normal.

The echocardiography showed: the enlargement of both atria and ventricles [LV: 61 (norm < 57), RV: 38 (norm < 27), La: 47 (norm < 40)], the overgrowth of the left ventricle (without contractility dysfunction (IVS-t was 13, norm 7–11). Small mitral recoil wave (+/++) was diagnosed.
Pulmonary hypertension was not diagnosed (TVPG was 26 mm Hg).

Other laboratory examinations showed hyperuricemia; the concentration of uric acid was 10.3 mg% (norm 3–7 mg%) and an impaired glucose tolerance (fasting glucose was 89 mg%; two hours after glucose administration it was 145 mg%). The uric acid concentration fell to 5.8 mg% after Allopurinol, in a dose of 200 mg/day, was applied.

After the application of autoCPAP and modification of the hypotensive treatment (the β-blocker and the ACE-inhibitor were supplemented by loop diuretic and an α-blocker) blood pressure normalization and reduction of body mass by around 9 kg (dehydration) (BMI: 43.4 kg/m²) was achieved.

During the autoCPAP treatment with 10 mbar, the rate of apneas and hypopneas decreased to 5.5 per hour of sleep. The OSA symptoms also significantly lessened (nycturia 0–1/night, morning tiredness and daily sleepiness stopped).

After a month of treatment with autoCPAP at home (the range of pressure 4–12 mbar) the patient tolerated the treatment with the autoCPAP well. The general condition of the patient was good. He reported for ambulatory check-up examination. Home (the range of pressure 4–12 mbar) the patient showed no side-effects of the treatment. During that month, the patient had lost a further 13 kg, and so was down to 127 kg (current BMI: 39.2 kg/m²).

Function tests showed significant improvement in the spirometry parameters (FVC: 3.92 L, 84% of normal, FEV₁: 2.96 L, 79% of normal, FEV₁ %FVC: 75.51%). As for the arterial blood gases, PaO₂ did not change substantially in comparison with the recent hospital results (67 mm Hg), but the PaCO₂ level had decreased to 44.7 mm Hg. The hematological parameters had normalized (erythrocytes: 4.55 G/L, Hgb: 15.6 g/dL, Hct: 45.9%).

**Discussion**

Considerable obesity and a severe form of OSA (61% of sleep time spent in desaturation) caused the patient’s respiratory insufficiency and secondary polycythemia. The patient was not diagnosed with features of pulmonary hypertension. PaO₂ normalization was reached after 10 days due to effective treatment of the OSA with the autoCPAP machine and dehydrating the patient (the decrease of body mass by 9 kg) and PaCO₂ was on borderline level. After a month of effective treatment with the autoCPAP and the loss of further 13 kg, the patient’s oxygenation was stable and did not improve further, but PaCO₂ and the hematological and spirometrical parameters normalized.

Kawata et al. [4] ascertained hypercapnia in 168 (14%) of 1227 patients with OSA. Those with hypercapnia had BMI and AHI significantly higher than patients with normocapnia. The spirometric parameters were similar in both groups. The analysis of logistic regression revealed that it was only the AHI that affected the occurrence of hypercapnia (p < 0.0001). As a result of three months’ treatment with the CPAP, hypercapnia receded in 51% of the patients (19 patients out of 51 treated with CPAP).

Banerjee et al. [5] compared the influence of the CPAP therapy on the structure of sleep during one night, AHI, the index of awakenings and oxygenation in two groups of patients with OSA (AHI ≥ 15, BMI ≥ 50 kg/m²). The first consisted of 23 patients solely with OSA and 23 patients with OSA and obesity hypoventilation syndrome (OHS) (PaO₂ < 70 mm Hg, PaCO₂ > 45 mm Hg, without coexisting pulmonary diseases). During the CPAP treatment the duration of REM phase, AHI, the rate of awakenings and the T90 time (SaO₂ < 90%) significantly improved. Despite applying CPAP, T90 > 20% was found in 43% of the patients with the coexisting OHS, compared to 9% in the group diagnosed solely with OSA.

Resta et al. [6] assessed the occurrence of hypercapnia in a group of 219 patients with OSA. Hypercapnia was found in 17% of them (PaCO₂ > 45 mm Hg). In the sub-group with hypercapnia, 13% were diagnosed with obesity hypoventilation syndrome, and 10% with overlap syndrome (COPD and OSA). The remaining 77%, were diagnosed as having solely OSA. In the patients with OHS, hypercapnia correlated with FVC (% of the predicted value), FEV₁ (% of the predicted value) and mean oxygen saturation of arterial blood at night.

Krieger et al. [1] examined the occurrence of pulmonary hypertension, hypoxemia and hypercapnia in a group of 114 patients with OSA (13% of the examined patients had hypercapnia) (PaCO₂ > 45 mm Hg). The occurrence of hypercapnia was associated with lower FEV₁ and minute ventilation, where PVR = 60 mm Hg and a longer period (in total) of apnea during sleep time. Hypoxemia was diagnosed in 33% of the patients (PaO₂ < 65 mm Hg). FEV₁ and AHI (positive and negative correlation for FEV₁ and AHI, respectively) had the strongest influence on the value of PaO₂.

Laaban and Chailleux [7] assessed the occurrence of hypercapnia in patients with OSA qualified for CPAP treatment (without coexisting obstructive or restrictive pulmonary diseases). In a group of 1141 patients, 11% were diagnosed with hypercapnia (PaCO₂ ≥ 45 mm Hg). The patients...
with hypercapnia had significantly higher BMI (p < 0.001) (the percentage of patients with hypercapnia increased from 7.2% in patients with BMI < 30 kg/m² to 23.6% in patients with BMI > 40 kg/m²) and lower: VC (p < 0.001), FEV₁ (p < 0.001) and PaO₂ (p < 0.001).

Brzecka et al. [8] examined the influence of CPAP treatment in 37 patients with OSA and hypercapnia (average PaCO₂ — 52 ± 6 mm Hg). In 36 patients, apneas stopped due to CPAP treatment. In 10 patients, night hypoxemia stopped (group I), while in 26 patients, despite the CPAP treatment, night hypoxemia persisted. The patients from the second group had: higher BMI, PaCO₂, and concentrations of hemoglobin and hematocrits and lower values of VC, FEV₁, PaO₂ and SaO₂ compared to the patients from the first group. In 16 patients (all from group II) polyglobulia was diagnosed.

Verin et al. [3] analyzed arterial blood gases (while awake) in two groups of patients with OSA (AHI > 15). The first group consisted of 125 patients with malfunction of the lungs and the second group consisted of 93 patients with regular lung function. Hypercapnia was diagnosed in 13.6% of patients from the first group and 4.3% from the second (PaCO₂ ≥ 6.0 kPa). 24.8% and 6.5% of patients respectively, from the first and the second group had hypoxemia. Multifactor analysis of the second group revealed a significant correlation between hypercapnia and the mean duration of the apnea and FRC. The occurrence of hypoxemia was influenced by: the mean duration of the apnea and BMI. In another study (of 456 patients with OSA) a negative correlation was found between the daily PaO₂ and the time spent in desaturation during sleep (SaO₂ < 90%) [9].

Recurrent episodes of night hypoxemia during apnea affecting patients with OSA (if the disease is not associated with another respiratory disease such as COPD) are seldom the cause of polyglobulia.

Carlson et al. [10] determined OSA in seven patients out of a group of nine with inexplicable polyglobulia (the number of erythrocytes correlated only with minimal SaO₂ during sleep time).

Zgierska et al. [11] described two patients with OSA and polyglobulia. The first of them had a severe form of the disease (AHI: 70/h of sleep) and spent 77% of sleep in overnight desaturation (T90) with the longest apnea lasting 146 seconds. The second patient was diagnosed with severe OSA (AHI: 53/h of sleep) and a severe form of COPD (FEV₁: 39% of norm). In the patient discussed in this study, severe desaturation during sleep time associated with OSA (T90: 61%) along with day hypoxemia (the impact of OSA, obesity) proved to be the causes of polyglobulia.

More frequently, in patients with OSA, a slight increase in the hematocrit value, hemoglobin and the number of erythrocytes has been observed, which reduces following the application of CPAP [12–15].

Conclusions

Function tests of the respiratory system (spirometry and arterial blood gases) are indispensable elements in diagnosing and treating OSA. Obstructive sleep apnea can also cause complete respiratory failure and polyglobulia (in particular in patients with severe overnight hypoxemia and giant obesity). The regression of the patient’s respiratory malfunction and polyglobulia were associated with effective treatment with the CPAP machine, a reduction of body mass and an improvement of spirometric parameters.

References