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Short term oxygen therapy effects in hypoxemic patients measured by drawing analysis

José Antonio Fiz[a,c,*], Marcos Faundez-Zanuy[b], Enrique Monte-Moreno[c], Josep Roure Alcobé[b], Felipe Andreo[a], Rosa Gomez[a], Juan Ruiz Manzano[a]

[a] Pulmonology Department, Hospital Universitari Germans Trias Pujol, Badalona, Spain[1]
[b] Escola Universitària Politècnica de Mataró, Tecnocampus Mataró, Spain[2]
[c] TALP Research Center, UPC, Barcelona, Spain[3]

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ABSTRACT

Background: Chronic hypoxemia has deleterious effects on psychomotor function that can affect daily life. There are no clear results regarding short term therapy with low concentrations of O_2 in hypoxemic patients. We seek to demonstrate, by measuring the characteristics of drawing, these effects on psychomotor function of hypoxemic patients treated with O_2.
Methods: Eight patients (7/1) M/F, age 69.5 (9.9) yr, mean (SD) with hypoxemia (P_a O_2 62.2 (6.9) mmHg) performed two drawings of pictures. Tests were performed before and after 30 min breathing with O_2.
Results: Stroke velocity increased after O_2 for the house drawing (i.e. velocity 27.6 (5.5) mm/s basal, 30.9 (7.1) mm/s with O_2, mean (SD), $p < 0.025$, Wilcoxon test). The drawing time 'down' or fraction time the pen is touching the paper during the drawing phase decreased (i.e. time down 20.7 (6.6) s basal, 17.4 (6.3) s with O_2, $p < 0.017$, Wilcoxon test).
Conclusions: This study shows that in patients with chronic hypoxemia, a short period of oxygen therapy produces changes in psychomotor function that can be measured by means of drawing analysis.

1. Background

Chronic hypoxemia has deleterious effects in neuropsychological and muscle function, with consequences in absent mindedness, perception, and realization of motor tasks [1]. These cognitive and motor function consequences can affect both daily life and relationships with surroundings. The underlying causes of cognitive and motor effects due to chronic hypoxia are a state of chronic systemic inflammation accompanied by oxidative stress directly affecting the neurons, with an increase in neurotransmitters. We posit that

* *Corresponding author at*: Pulmonary Department, Hospital Universitari Germans Trias I Pujol, Planta 8, Carretera del Canet s/n, 08916 Badalona, Spain.
E-mail addresses: jafiz@msn.com (J.A. Fiz), faundez@eupmt.es (M. Faundez-Zanuy), enric.monte@upc.edu (E. Monte-Moreno), roure@tecnocampus.cat (J.R. Alcobé), fandreo@separ.es (F. Andreo), gomezmendezrosamaria8@gmail.com (R. Gomez), jruizmanzano.germanstrias@gencat.cat (J.R. Manzano).
[1] Tel.: +34 93 497 8920.
[2] Tel.: +34 93 169 6501.
[3] Tel.: +34 93 401 6435.

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oxygen therapy would increase the concentration of oxygen at the brain, which should improve the physiological state of the areas related to cognition.

There are no clear results regarding the effect of low concentrations of O_2 on cognitive state in hypoxemic patients. Some studies did not report any effects and others described positive ones [1–6]. Pretto et al. showed that acute oxygen therapy did not improve cognitive and driving performance in chronic hypoxemic pulmonary obstructive disease patients (COPD) [6]. Conversely, regular use of supplemental oxygen therapy decreased the risk for cognitive impairment in patients with COPD [1]. It is probable that the difference among these results is due to the fact that tests are not completely sensitive to O_2 changes, or are dependent on disease severity [7]. There is however unanimity regarding their effect on the improvement of life expectancy or on variables such as the 6 min walking test, red cell number or arterial lung pressures [8–10]. On the other hand, hypoxemic COPD seems to have a cognitive impairment profile different from that of normal and demented subjects, with verbal memory and praxic/executive function being the most affected, as shown by Antonelli et al. [7]. The aim of this study was to propose a method that can be done in the patient's home, does not require specialized health technical support and reflects the fine motor brain control [11].

2. Material and methods

Eight patients (7/1 M/F), who had hypoxemia more than five years participated in the drawing task study. All had completed primary education and were in a stable condition. All studies were performed by the same physician. The study was conducted in the Respiratory Function Laboratory at Germans Trias i Pujol University Hospital (HUGTIP), and approved by the Human Research and Ethics Committee of the hospital. All participants gave written informed consent as required by the Institutional Review Board, following the World Medical Association's Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects.

Participants were without any diagnosis of writer's cramp. The exclusion criteria were: current smoking habit, high caffeine consumption, hand tremor, neurologic, rheumatic or endocrine diseases and history of drug or alcohol abuse, as well as central nervous system or psychiatric disorders. Neurology and psychiatric disorders were discarded by respective departments.

At baseline, lung function was measured by spirometry (Hyp'Air Compact, Medisoft). Measurements were obtained in accordance with the established guidelines and results compared to normative data [12,13]. Arterial radial gasometry was measured by means of a Gen Premier 3000 analyzer (MedWrench. Bedford Massachusetts. USA) at basal and after 30 min with O_2 at 3 l/min by nasal plugs.

Drawing analysis was made using a digitizing tablet with an ink pen (Wacom Co, Intuos$_4$, US). All drawing tasks were performed on A4 size liner paper attached to the tablet surface. The drawing tasks reflected perceptual-motor complex functions and cognitive aspects that appear when copying a new figure never seen before. A total of 2 exercises were carried out, repeating them three times before and after 30 min with nasal O_2 at 3 l/min, continuing with O_2 administration during the second part of the test. A complete test session took two and a half hours, and was performed between 09:00 and 11:30 AM. Researchers asked patients to perform drawing tasks: two pictures (a house, a clock). A 30 s interval was given between the single trials.

The digitizing tablet acquires 200 samples per second, including the spatial coordinates (x, y), the pressure, altitude and azimuth [14]. The digitizer provides accurate measurement when the pen is touching the tablet and when it is lifted 6 mm above the digitizer [15].

The analyzed parameters were: pressure, mean velocity, acceleration, time down, time up, entropy, first and second derivatives of pressure and entropy. Mean speed was calculated as positional coordinate x and y derivatives, with respect to time according to:

$$\text{mean (velocity)} = \text{mean}\left(\sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}\right)$$

where x and y are the spatial coordinates of object drawing.

Time down is the time when the pen rests touches on the tablet and time up is the time with the pen off the tablet.

Mean pressure was measured toward the writing surface in continuous non-scaled units from 0 to 2047 [16].

Entropy $H(X)$ was calculated considering that the random variable X consists of several events, which occur with probability $p(x)$ and can be calculated according to the equation [17]:

$$H(X) = -\sum_{x \in X} p(x)\log_2(p(x))$$

In the present study, entropy was calculated for the first and second derivative of pressure. Entropy measures the information contained in a signal. Thus, entropy of pressure is the information content of the pressure profile executed by the drawer and is measured in bit units, after applying $\log_2$.

2.1. Statistical analysis

Descriptive statistics (mean, standard deviation, 95% of confidence interval, intra-subject coefficient of variation), were used to describe the variables. Non parametric tests for paired data were applied (Wilcoxon matched pair test and Friedman ANOVA). For comparisons, a probability less than 0.05 was considered as significant.

3. Results

Table 1 shows anthropometric, demographic and spirometric characteristics of hypoxemic patients. Mean age was 69.5 (9.9) yr, mean height was 164.1 (8.11) cm, and mean body max index (BMI) 24.9 (4.1) kg/m^2. All patients were ex-smokers with a mean of 30 packs/yr, except for the woman who never smoked. All patients had a moderate-severe airway obstruction except for the female who was affected by an idiopathic pulmonary fibrosis, and patient three who had undergone a thoracoplasty. Patient eight had also undergone a left pneumonectomy for non small cell lung cancer.