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RESEARCH ARTICLE

The effect of nasal polyposis related nasal obstruction on cognitive functions

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Abstract

Chronic rhinosinusitis with nasal polyposis is a chronic inflammatory disease of the respiratory mucosa of the nasal cavity and paranasal sinuses. The aim of this study was investigate the effect of nasal obstruction related to chronic rhinosinusitis with nasal polyposis on cognitive functions. Patients with chronic rhinosinusitis with nasal polyposis causing bilateral total or near total nasal obstruction were enrolled in the study. Symptoms of nasal congestion, loss of smell, postnasal drip, headaches, snoring, concentration difficulties and blunted affect were evaluated by Visual Analog Scale. Brief symptom inventory test, Stroop test, visual aural digit span, serial digit learning test and P300 test were used to evaluate cognitive functions. Three months after treatment, the tests done before surgery were repeated and the results were compared. A total of 30 patients were included in the study. On the Visual Analog Scale, all symptoms showed significant postoperative improvement in all patients ($p < 0.001$ for all symptoms). Preoperative nasal congestion accompanied with impaired concentration were detected in 27 patients (90%), and these symptoms recovered in all these patients after treatment ($p = 0.035$) (correlation coefficient 0.4). Only 22 patients completed the neuropsychological tests. The mean preoperative Stroop test (23.16 ± 5.30), visual aural digit span test (24.68 ± 3.52), and serial digit learning test (16.18 ± 5.35) scores were showed significant improvement compared with mean postoperative Stroop test (21.12 ± 5.69), visual aural digit span test (26.45 ± 2.98), and serial digit learning test (19.31 ± 4.47) scores ($p = 0.047$, $p = 0.022$, $p = 0.005$ respectively). The postoperative P300 latency values improved in 19 (63%) patients. The preoperative and postoperative latency values for P300 showed a significant difference ($p = 0.029$), whereas the preoperative and postoperative amplitude values for P300 did not differ ($p = 0.096$). In conclusion, the results of this study indicate that chronic rhinosinusitis with nasal polyposis (CRSwNP) has negative effects on cognitive functions, such as the ability to focus and maintain concentration. These cognitive functions improve after the patients undergo endoscopic sinus surgery to treat their CRSwNP.

Keywords Cognitive function · Nasal polyposis · Endoscopic sinus surgery · Nasal obstruction · P300

Introduction

Chronic rhinosinusitis with nasal polyposis (CRSwNP) is a chronic inflammatory disease of the respiratory mucosa of the nasal cavity and paranasal sinuses (Andrews et al. 2005). Despite of its most common symptom is nasal obstruction; other frequent complaints include hyposmia, postnasal drip, rhinorrhea, headache, and snoring (Alobid et al. 2005; Nguyen et al. 2015). These patients have to limit their daily activities and social relationships due to these nasal symptoms (Adnane et al. 2015; Alobid et al. 2005; Soler and Smith 2010). An exhaustive history of patients with CRSwNP reveals that may have poor sleep quality and impaired attention and perception during the daytime (Tosun et al. 2009). Deterioration in cognitive function, such as mood changes and difficulty in concentration may be seen among the symptoms of CRSwNP with detailed medical history. Cognitive function is the function that shows the highest capacity of function in the human

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brain and consists of several processes, such as learning and remembering information, organization, planning, problem solving, focusing and maintaining attention, perception of the environment, and calculation (Karabekiroğlu et al. 2005). These functions can be impaired by neurological and psychiatric disorders, chronic obstructive pulmonary disease associated with chronic hypoxia, Obstructive sleep apnea syndrome (OSAS) accompanied by atherosclerotic vascular disease, and nocturnal hypoxia (Goodin and Aminoff 1992; Hrubos-Strom et al. 2012; Karamanli et al. 2015; Polich et al. 1986; Sarıkaya et al. 2014). The aim of this study was investigate presence of the effect of nasal obstruction related to CRSwNP on cognitive functions.

Materials and methods

This study was carried out in our tertiary hospital between March 2013 and January 2015, with the approval of the local ethics committee (Gülhane Military Medical Academy-Ankara/Turkey, 15.02.2013/1491-153-13/1648.4-423). Patients with CRSwNP were enrolled in the study after informed consent was obtained. Polyp extent was graded on the basis of a 3-point classification system (1, confined to middle meatus; 2, below level of middle turbinate but not causing total obstruction; 3, causing total obstruction). Patients with CRSwNP causing bilateral total or near total nasal obstruction (Stage 3) were enrolled in the study. Stages 1 and 2 CRSwNP patients were excluded. Other exclusion criteria were the following; patients younger in age than 18 years, or those with acute rinosinusitis, nasal anatomical deformity causing nasal obstruction, vasomotor rhinitis or allergic rhinitis confirmed by skin tests, nasal tumor, nasal congestion caused by systemic disease such as hypothyroidism, mental and neuropsychological disease, psychological drug use, or poor hearing. Patients who had OSAS confirmed by polysomnography were excluded, and no patients enrolled in this study had any witnessed apneas or awoke with choking sensations.

CRSwNP and chronic sinusitis were evaluated in all patients using anterior rhinoscopy, endoscopy, and paranasal sinus tomography. All patient had massive nasal polyposis obstructing nasal cavityand on CT for each side. Preoperative nasal congestion, postnasal drip and rhinorrhea, smell disturbance, headache, snoring, impaired concentration, and blunted affect symptoms were rated using a 10 cm visual analog scale (VAS) form. The Stroop test, brief symptom inventory test (BSI), visual aural digit span test B (VADS-B) and serial digit learning tests (SDL) were then conducted to evaluate cognitive functions in the Department of Psychiatry. The patients were to stop taking any medications that could affect attention 1 week before the tests. The patients had no significant problems about their lives on the test day and they had not taken alcohol or narcotic drugs for 1 day before the test. The upper age limit was 54 years and the training period was at least 8 years in duration to allow evaluation and application of neuropsychiatric tests. Consequently, neuropsychiatric tests were not performed on 2 patients who were over 54 years of age or on 6 patients who had fewer than 8 years of education (8 patients in total). These eight patients underwent P300 and other evaluations. Only 22 patients completed the neuropsychological tests.

The Stroop Test TBAG Form was used to evaluate ‘intensification and sustainability of attention’, ‘ability of resistance towards disruptive stimulus,’ ‘stopping and suppressing of inappropriate warning and reaction tendency.’ The Stroop Test consists of five stages. In the first stage, the reading velocity of four color names written in white and black was recorded. The next stage consisted of reading the same color names written in different colors. The last stage consists of stating the text color of color names written in different colors. In all stages of the test, the numbers of errors and corrections were recorded. In our study, reading times of fifth card were used to evaluate the attention and disruptive effects.

The VADS-B was used to assess the capacity-limited and short-term memory. This test consists of four subtests, in which different lengths of number sequences are presented to individuals by auditory and visual stimuli and then their oral or written responses are assessed. Ten points are calculated by subtests and a combination of points, and the final point is calculated by the sum of these points. In our study, the eleventh point showing total points was used.

Two different number sequences involving 8 or 9 number strings of numerals between 1 and 9 were used to assess SDL. The sequences were chosen and read to the individuals according to their ages and education levels. The individual was asked to remember the correct order and repeat it. This was repeated twelve times. When the individual remembered the order twice correctly, the test was stopped. The number of attempts and the total scores of exact learning were taken into account.

The BSI Test, a multidimensional symptom screening scale used to detect various psychological and medical diseases, was applied to individuals while situated alone in a silent and adequate lit room. The total points obtained from answers to 53 questions were taken into account.

Event-related auditory evoked potentials (P300) were recorded with an EMG device (4-channel Natus brand Synergy model 2008, USA) in a silent and brightly lit room in the Neurophysiology Laboratory of the Neurology Department. Sleep Sense gold electrodes with Ten20

Conductive neurodiagnostic electrode posts were used. The active electrodes were placed at the Fz, Cz, C3, and C4 points according to the international 10–20 system, and the recordings were made by taking both mastoid areas as reference points. Impedances were held lower than 5 kΩ. Auditory stimuli were given at 60 dB higher than the equal hearing value, towards both ears. The frequency of the untargeted stimulus was determined as 1800 Hz, while the target frequency was 2800 Hz. The stimulus frequency was determined as 0.7/s. After informing the patients about the test, the target and untargeted sounds were introduced. The patient was requested to count the target sounds, which made up twenty percent of the total sounds and occurred randomly. The recording was continued until 40 target sounds were recognized. The recordings were repeated twice. While analyzing the data, Cz recording points were assessed.

All patients underwent endoscopic sinus surgery after the preoperative medical regimen as recommended by current treatment guidelines and were given topical steroid treatment for postoperative 3 months. The tests done before surgery were repeated 3 months after the surgery. The results obtained before and after treatment were compared. SPSS for Win. Ver. 15.0 (SPSS Inc., Chicago, IL., USA) was used for data analysis. The Wilcoxon test, and Spearman correlation analysis test were used for data comparisons. Statistically, $p < 0.05$ was accepted as a significant value.

Results

A total of 30 patients [26 (87%) men and 4 (13%) women] aged between 21 and 72 years (mean age 40.13 ± 13.25 years) were included in the study. All cases that had preoperative total nasal obstruction showed improvement in their nasal obstructions. The mean preoperative nasal obstruction severity was 8.40 ± 0.77, whereas the postoperative nasal obstruction severity mean was 1.20 ± 1.42. A significant difference was noted between the nasal obstruction values for the preoperative and postoperative (3rd month) assessments ($p < 0.001$) (Table 1). All symptoms, including rhinorrhea, impaired smell, postnasal drip, headache, snoring, impaired concentration, and blunted affect, recovered significantly in all patients who stated these complaints (all $p < 0.001$) (Table 1). Preoperative nasal obstruction, accompanied with impaired concentration symptom, were detected in 27 patients (90%), and these symptoms recovered in all these patients ($p = 0.035$) (correlation coefficient = 0.40). Preoperative nasal obstruction, accompanied with blunted effect symptom, were detected in 21 patients (70%), and these symptoms recovered in all these patients ($p = 0.024$) (correlation coefficient = 0.45).

Only 22 patients completed the neuropsychological tests, because eight patients did not meet the education and age requirements of the tests. The mean preoperative Stroop test score was 23.16 ± 5.30, whereas the postoperative mean Stroop test score was 21.12 ± 5.69. The mean preoperative SDL test score was 16.18 ± 5.35, whereas the postoperative mean SDL test score was 19.31 ± 4.47. The mean preoperative VADS-B test score was 24.68 ± 3.52, whereas the postoperative mean VADS-B test score was 26.45 ± 2.98. All 22 cases showed significant improvement in the Stroop test, SDL test, and VADS-B test scores (respectively $p = 0.025$, $p = 0.005$, $p = 0.022$). The BSI Test scores also improved; however, the difference was not statistically significant ($p = 0.065$) (Table 2).

The mean preoperative latency of P300 was 326.46 ± 25.90, whereas the postoperative value was 315.13 ± 22.86. The mean preoperative amplitude of P300 was 15.85 ± 8.01, whereas the postoperative value was 17.91 ± 7.13. The preoperative and postoperative P300 latencies showed a significant difference ($p = 0.029$), whereas the preoperative and postoperative P300 amplitudes did not differ ($p = 0.096$) (Table 3).

Discussion

Cognitive functions involve many psychological concepts, including attention, expectation, astonishment, and the storage of information in memory. Studies on cognition in patients with diseases related to Chronic rhinosinusitis with nasal polyposis (CRSwNP), such as allergic rhinitis and chronic rhinitis, and Obstructive sleep apnea syndrome (OSAS) have shown that cognitive functions can deteriorate in association with these disorders (Bhattacharyya 2012; Csábi et al. 2012; Inoue et al. 2013; Meltzer et al. 2009; Sangal and Sangal 1997; Tarasidis et al. 2015). The possible mechanisms for this cognitive dysfunction include differential neural activation secondary to chronic pain and/or the sequelae of a chronic inflammatory state (Tarasidis et al. 2015). The cognitive changes in patients with severe nasal obstruction may also arise, in part, due to sleep disturbance and OSAS. Although CRSwNP has a well-known association with a high prevalence of pathological sleep dysfunction, information on cognitive functions related to nasal polyposis is scarce. Detailed histories may show that patients with CRSwNP have complaints related to cognitive functions. The results of the present study indicate that most patients (90%) had symptoms of both nasal congestion and difficulty in concentration.

Table 1 Preoperative and postoperative symptom severity

n = 30	Complainant patient number	Recovered patient number	Symptom severity (mean ± SD)		*p* value
			Preoperative	Postoperative	
Nasal congestion	30/30 (100%)	30/30 (100%)	8.40 ± 0.77	1.20 ± 1.42	< 0.001
Rhinorrhea	23/30 (77%)	23/23 (100%)	5.03 ± 2.94	1.34 ± 1.24	< 0.001
Impaired smell	28/30 (93%)	26/28 (93%)	7.60 ± 2.35	2.70 ± 2.42	< 0.001
Postnasal drip	26/30 (87%)	26/26 (100%)	5.90 ± 2.60	2.06 ± 1.20	< 0.001
Headache	25/30 (83%)	25/25 (100%)	5.33 ± 2.75	1.00 ± 1.01	< 0.001
Snoring	27/30 (90%)	25/27 (93%)	7.36 ± 2.84	2.16 ± 2.00	< 0.001
Diffuculty in concentration	27/30 (90%)	27/27 (100%)	6.63 ± 2.53	1.40 ± 0.96	< 0.001
Blunted affect	21/30 (70%)	21/27 (100%)	4.26 ± 3.05	1.00 ± 0.94	< 0.001

Table 2 Preoperative and postoperative cognitive test results of patients group

n = 22	Postoperative test points (patients number)			Preoperative score mean ± SD	Postoperative score mean ± SD	*p* value
	Improvement	Stable	Deterioration			
Stroop TBAG	16/22 (73%)	–	6/22 (27%)	23.16 ± 5.30	21.12 ± 5.69	0.025
SDL test	16/22 (73%)	2/22 (9%)	4/22 (18%)	16.18 ± 5.35	19.31 ± 4.47	0.005
VADS-B	14/22 (64%)	3/22 (14%)	5/22 (22%)	24.68 ± 3.52	26.45 ± 2.98	0.022
BSI)	14/22 (64%)	1/22 (5%)	7/22 (31%)	24.18 ± 16.84	20.40 ± 22.91	0.065

STROOP TBAG STROOP test for basic science research group, *SDL* serial digit learning, *VADS-B* visual aural digit span test B tests, *BSI* brief symptom inventory test

Table 3 Preoperative and postoperative P300 results comparisons in patient group

(n:30)	Preoperative	Postoperative	*p*
Latancy (ms)	326.46 ± 25.90	315.13 ± 22.86	0.029
Amplitude (μV)	15.85 ± 8.01	17.91 ± 7.13	0.096

The nose plays an important role in sleep quality. Patients with chronic rhinosinusitis and CRSwNP complain of several sinonasal symptoms that impact their sleep and their quality of life (Jiang et al. 2016; Soler et al. 2015; Tarasidis et al. 2015; Tosun et al. 2009; Zwillich et al. 1981). CRSwNP-related snoring and impaired sleep quality result in concentration distraction, social inhibition, and mood defects (Tosun et al. 2009). Sleep problems were correlated with the symptom of nasal obstruction (Jiang et al. 2016; Suratt et al. 1986). The symptom-related sleep disturbance reported by patients and attributed to nasal obstruction is significantly reduced after CRSwNP surgery (Nguyen et al. 2017). Although current thinking emphasizes the contribution of diffuse sinonasal inflammation to both cognitive dysfunction and CRSwNP, the cognitive changes observed in patients with severe nasal obstruction may be related to OSAS.

The Stroop Test is a neuropsychiatric test that shows activities of the frontal area. It has been used for measuring selective attention capacity, disruptive impact resistance, and speed of information processing in patients with stroke, depression, and obsessive–compulsive disorder (Hidese et al. 2016). This test was also used successfully for measuring attention in patients with OSAS. It is stated that STROOP interference time is prolonged in patient with severe OSAS (Hrubos-Strom et al. 2012). We used the Stroop test to measure selective attention capacity, response inhibition, disruptive impact resistance and speed of information process. After treatment, the 5th card reading times were significantly shorter ($p = 0.025$), indicating clinical improvement.

The serial digit learning tests (SDL Test) is useful in evaluating cognitive processing, such as learning and short term memory, and it has been used in various disease groups, like depression and hydrocephaly (Bakar and Bakar 2010; Demir et al. 2013). This test has also been used in OSAS to assess cognitive function. Patients with these diseases have worse results than control groups (Demir et al. 2013; Saunamäki et al. 2010). In our study, the SDL Test scores showed significant improvement in

cognitive function in 73% of our patients after surgery ($p = 0.005$).

The visual aural digit span test B (VADS-B) is a neuropsychiatric test that measures short term memory, sequencing, and sensory motor integration. It has been used to measure cognitive activity especially in patients with epilepsy and attention deficit and hyperactivity disorder. The literature does not contain any studies on ear, nose, and throat disorders that have used this test. However, some studies have evaluated short term memory functions with the Rey Auditory Verbal Listening Test (RAVLT) in patients with OSAS, where these patients have lower performance compared to control groups (Hrubos-Strom et al. 2012; Weiss et al. 2009). In the present study, a significant cognitive function improvement was seen in 64% of our patients ($p = 0.022$) according to their VADS-B scores.

The P300, which measures cognitive functions and attention, is a positive wave whose latency can be seen at 200–500 ms in normal healthy persons (Işıntaş et al. 2019). The amplitude of this wave can be recorded as the highest on the surface of parietal and central zone midlines (Sarıkaya et al. 2014). The P300 wave arises in response to a target stimulus. Its latency reveals the evaluation time of response to the target stimulus, while its amplitude reveals attention and cognitive function related to the importance of the stimulus and expectation (Kutas and Hillyard 1990). Disturbed cognitive functions appear as prolonged latency and decreased amplitude. This test has been used in patients with OSAS and allergic rhinitis (Csábi et al. 2012; Inoue et al. 2013; Meltzer et al. 2009; Sangal and Sangal 1997), where the latency of P300 was prolonged in OSAS patients compared to healthy groups before treatment (Inoue et al. 2013). Meltzer et al. 2009 found that cognitive functions of patients with allergic rhinitis were negatively influenced, based on a P300 study. In our study, the mean preoperative latency of P300 showed significant improvement after treatment ($p = 0.029$). Conversely, the mean postoperative amplitude of P300 did not differ significantly after treatment ($p = 0.096$). Although the mean latency of P300 showed a statistically significant improvement ($p = 0.029$), a P300 latency can be seen at 200–500 ms in normal healthy persons, so this observed difference in P300 latency between the preoperative and postoperative conditions may have no clinical significance.

Conclusion

The findings of this study indicate that cognitive functions, such as selective attention capacity, short time memory, sequencing, and sensory motor integration, worsen because of nasal obstruction related to CRSwNP. However, patients with OSAS confirmed by polysomnography were excluded from the study, and no patients who were enrolled had any witnessed apneas or awoke with choking sensations. Therefore, the cognitive changes in our patients with severe nasal obstruction could have been due, in part, to OSAS-related nasal polyposis. Although specific evidence derived from objective measurements is lacking, the appropriate treatment of CRSwNP appears to provide subjective improvement in cognitive functions. Additional studies should be conducted to extend these findings.

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Author's contributions FA study design, manuscript preparation; FA, SC measurements, manuscript proofreading, statistical analysis; AD manuscript proofreading; FT working group leader, manuscript proofreading.

Compliance with ethical standards

Conflict of interest No conflict of interests.

Ethical approval The study began after the approval of the local ethics committee was obtained.

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