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Impact of Controlled Induced Hypotension on Cognitive Functions of Patients Undergoing Functional Endoscopic Sinus Surgery

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Background: Controlled induced hypotension guarantees less blood loss and better visibility of the surgical site. The impact of hypotension on post-operative cognitive functions is still being discussed. The objective of this study was to evaluate the effects of controlled induced hypotension on the cognitive functions of patients undergoing functional endoscopic sinus surgery (FESS).

Material/Methods: We allocated 47 patients with a good grade of preoperative cognitive functions evaluated with the Mini-Mental State Examination to 3 groups (1 – mild hypotension, 2 – intermediate hypotension, 3 – severe hypotension) according to the degree of mean intraoperative arterial pressure compared with preoperative blood pressure. Cognitive functions were evaluated preoperatively, 6 h, and 30 h postoperatively with standardized tests: the Stroop Test, Trail Making Test (TMT), and Verbal Fluency Test (VFT). A decrease in the test results and increase in the number of mistakes made were considered an impairment of cognitive functions.

Results: A total of 47 patients (group 1 – mild hypotension – 15, group 2 – intermediate hypotension – 19, group 3 – severe hypotension – 13) were included in the study. A significant decrease was observed in all the 3 groups after Stroop A test 6h postoperatively but it improved 30h postoperatively, without differences between the groups. Neither a significant decrease in the test results nor an increase in the number of mistakes was noted for Stroop B tests, TMT A&B tests and VFT.

Conclusions: The degree of controlled intraoperative hypotension during FESS did not influence the results of psychometric tests.

MeSH Keywords: **Cognition • Hypotension, Controlled • Sinusitis • Speech Disorders • Stroop Test • Trail Making Test**

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Background

Controlled induced hypotension is a common procedure during anaesthesia applied to patients undergoing, among others, endoscopic sinus interventions. Decreased blood pressure allows reduction of bleeding in the surgical field, minimization of blood loss, better visibility and therefore, it increases the surgeon's comfort, reduces the surgery time and prevents complications emerging from blurred vision caused by coverage of the camera lens with blood [1,2].

Studies have shown a variety of methods reducing bleeding in the surgical field through: lowering the mean arterial pressure (MAP), lowering HR, local anemization with adrenaline, preoperative use of steroids (which reduce the inflammatory reaction, damage to the blood vessels, edema, and adrenergic receptors activation), and reversing the Trendelenburg position, which reduces blood supply in the surgical field. Significant improvement of surgical conditions has been noted with a MAP of 65 mmHg. Magnesium, nitroglycerin, ACEI (angiotensin converting enzyme inhibitors), calcium channel blockers, beta-blockers, sodium nitroprusside, clonidine, and large doses of inhalational anaesthetics have all been used to achieve the target MAP.

Drug-induced vasodilatation is only beneficial if the cardiac output (CO) is reduced. Therefore, prevention of reactive tachycardia is necessary. It can be achieved through the administration of labetalol, a short-acting beta-blocker, which stabilizes the HR at 60 bpm and simultaneously reduces the MAP. Taking into consideration the CO values as an index of both perfusion and bleeding, it is reasonable to stabilize it within lower normal range values [2–6]. Additionally, remifentanil (RFN), an ultrashort-acting opioid and μ receptor agonist, also plays an important part in endoscopic surgery of paranasal sinuses. It enables easy adjustment of the depth of anaesthesia and reduction of the MAP and HR through cardiodepressive action [6,7]. Earlier studies also indicated the positive effect of propofol as an anaesthetic in reducing MAP through its effect on precapillary arterioles. However, it has relatively little effect on the myocardium. Moreover, when compared with the combination of sevoflurane and RFN, no significant differences in intraoperative bleeding were observed. Additionally, this combination enables continuous monitoring of the volatile anaesthetic concentration as well as easy adjustment of MAP during the procedure [4,8]. Some studies have also shown that the return of cognitive functions to the initial level within the first hour seems to be faster in patients on sevoflurane than in those on propofol [9,10].

Although the positive effects of controlled hypotension (including reduced blood loss, time of intervention, and increased comfort of the surgeon) are well known, the method is still limited by concerns regarding the impact of severe hypotension. Permanent brain damage, emboli in cerebral circulation, difficult awakening of the patient, and even death – all these complications might occur when hypotension is too deep [1,7]. The cerebral blood flow (CBF) is controlled by different metabolic, chemical (pO2, pCO2), and neural mechanisms and autoregulation. Under physiological conditions, CBF remains constant despite MAP changes from 50 to 150 mmHg. Brain ischemia, injuries, arterial hypertension, and other pathological and pharmacological factors may disturb the mechanisms of autoregulation. Volatile anaesthetics used in anaesthesia may limit or even abolish autoregulation of CBF, thus increasing the vulnerability of brain tissues to MAP alterations during surgery [11,12].

Although brain tissues are susceptible to hypoxemic damage, research has shown that lowering the MAP to 2/3 of the initial value does not cause any damage [13,14]. On the other hand, there is no evidence that these conditions influence the epidemiology of functional disorders, especially those affecting cognitive functions. Earlier studies confirmed the impact of the patient's initial general condition, age, accompanying diseases, drugs, and addiction to psychoactive substances on cognitive functions. The influence of iatrogenic factors, including the duration of hospitalization, time of surgical procedure, and drugs administered, has also been noted [15].

One of the main factors influencing patients' condition is the quality of anaesthetic management, including hemodynamic stability. Maintaining homeostasis of body functions is the golden rule of proper anaesthetic management and it is crucial to minimize complications.

The objective of this study was to evaluate the effects of controlled induced hypotension on the cognitive functions of patients undergoing functional endoscopic sinus surgery (FESS).

Material and Methods

The study was approved by the Bioethics Committee of the Poznań University of Medical Sciences (decision number 298/13) and was conducted in accordance with the Declaration of Helsinki. The study was conducted on patients undergoing Functional Endoscopic Sinus Surgery in Heliodor Święcicki University Hospital in Poznań between 16 April and 18 June 2013 and between 15 October and 20 December 2014. The inclusion criteria were as follows: age 18-75, good mental status confirmed with the Mini-Mental State Examination (MMSE) minimum score of 27 points, no drugs taken that influence cognitive functions, no vision impairment or vision corrected with glasses, and no severe hearing disorders influencing the quality of communication. Patients with poorly controlled

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Table 1. Demographic data, initial Mini-Mental State Examination result and ASA scale result of patients in groups.

	N	Women	Men	Age	MMSE	ASA
Together	47	17	30	45.7±16.0	28.9±1.3	1.7±0.6
Group 1 – mild hypotension (MAP_{mn}/MAP0 >75%)	15	7	8	43.4±21.0	28.9±1.4	1.7±0.7
Group 2 – intermediate hypotension (65%< MAP_{mn}/MAP0 ≤75%)	19	6	13	45.1±13.9	29.2±1.0	1.6±0.6
Group 3 – severe hypotension (MAP_{mn}/MAP0 ≤65%)	13	4	9	49.3±13.1	28.5±1.5	1.8±0.4

hypertension, ischemic disease, and autonomic system impairment were excluded from the study. All the subjects in the study were able to communicate in Polish and had no manual dysfunctions.

During the trial period, 84 patients were qualified, 76 of whom agreed to take part: 3 of them were disqualified due to pre-existent disorders of cognitive functions, with the MMSE score under 27 points, 1 person due to daltonism (which makes it impossible to complete the Stroop Test), and 3 people due to psychiatric drugs taken. Moreover, 21 patients withdrew on the day of the surgery, as they did not feel well enough to complete the psychometric tests. In 1 case, the surgery (mFESS) was too short to achieve the target MAP and this patient was excluded from the study. Eventually, 47 patients (American Society of Anesthesiologists – ASA score 1–3) were qualified for the study: 30 men (64%) and 17 women (36%), with a mean age of 46 years (SD 16).

During the surgery, the anesthesiologists set the target MAP according to the patient's general condition as well as their own experience and preferences. The patients were allocated to 3 groups postoperatively, according to the mean MAP during the surgery as a fraction of the preoperative MAP ($MAP_m\%MAP_0$): group I – mild hypotension ($MAP_m\%MAP_0$>75%), group II – intermediate hypotension (65%< $MAP_m\%MAP_0$ ≤75%), and group 3 – severe hypotension ($MAP_m\%$ MAP_0 ≤65% with the minimum value of 53%).

The groups were homogenous in terms of age, gender, BMI, initial results of basic blood tests, and the MMSE result. Table 1 shows the demographic data and results of the screening test.

One day before the surgery, all the patients qualified for the study completed psychometric tests, which evaluated cognitive functions: the Stroop Test, Trail Making Test (TMT), and Verbal Fluency Test (VFT)

In the Stroop test variant A, the patient's task is to say aloud the names of colors printed on a sheet of paper. Variant B evaluates the speed of naming colors in which the names are printed, but none of the names are printed in the proper color. The Stroop test evaluates the interference of ambiguous stimuli describing colors, which prolongs the reaction time when the patient has to react to a new criterion. The larger the difference between variants B and A is and the number of mistakes made, the more impaired the cognitive functions are. The prefrontal cortex, cingulate cortex, cerebellum, and basal nuclei are all activated while the patient is performing this test [16–19]. The Stroop test was also used in the largest multicentre trials ISPOCD 1 and 2, evaluating patients undergoing non-cardiosurgical interventions.

In the TMT, the patient has to connect dots: in variant A they represent numbers (1, 2, 3, … 25), in variant B – numbers and letters, alternately (1, A, 2, B, 3, C, … 12, K). This test was first used to evaluate general intelligence in the US Army. Nowadays it has been adapted to assess cognitive functions. It allows assessment of scanning, processing speed, and mental elasticity [17,18,20–27]. Version B additionally assesses visual-spatial operational memory [26–29]. The faster the task is completed, the better the cognitive functions are.

The VFT evaluates both semantic (categorical) and phonemic (such as 'words that begin with the letter…') verbal fluency. For each of 6 categories (semantic: animals, vegetables, fruits; phonemic: S, L, N) the number of unique words given by the patient within 1 minute was registered. The number of errors was also recorded. The VFT needs access to long-term memory (LTM), processing functions, executive functions, and memory processes [20,30–33].

On the day of the surgery, 1 hour before induction, all the patients were administered midazolam (7.5–11.25 mg). An invasive blood pressure (IBP) cannula was inserted under topical anaesthesia immediately before induction. All the patients were anesthetized identically – after 3-minute oxygenation with 100% O_2 anaesthesia was induced with propofol (1.5–3 mg/kg), RFN (0.4 µg/kg/h), rocuronium (5 mg) and suxamethonium (0.5–1 mg/kg). Anaesthesia was maintained with RFN

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(0.05–0.5 µg/kg/h) and sevoflurane (0.6–0.9 MAC), according to the patient's individual needs. During the procedure, ECG, SpO_2, HR, MAP, $etCO_2$, FiO_2, and peak airway pressure (PAP) were controlled continuously and the values were noted every 5 minutes. The flow of sevoflurane and RFN was stopped when the surgery terminated.

In 18 cases (38%), the anesthesiologist decided to administer ephedrine (5 mg) to raise the MAP after lowering it below the target value.

There were 37 patients who underwent the tests 3 times – on the day before the surgery (Day 1), on the day of the surgery (Day 2), and on the day following the surgery (Day 3). Ten patients were discharged in the morning on the day following the surgery due to good general condition, which made it impossible to complete the tests for the third time. The tests were conducted every day between 6 pm and 9 pm. On the day of the surgery, the tests were conducted postoperatively, at least 3 hours after the surgery. Differences in the results on each day and the number of mistakes were analyzed.

The results were analyzed statistically with STATISTICA 10.0 StatSoft, Inc. (2011). The basic demographic data and the results of the screening tests were presented as the mean and standard deviation. The distribution of the demographic data, Stroop Test results, TMT results, VFT results were analyzed with the Kolmogorov-Smirnov test.

The differences in the test results between the groups were analyzed with ANOVA for dependent variables. Friedman's ANOVA was used to investigate the number of mistakes made, due to their non-Gaussian distribution.

In all the statistical tests, $p<0.05$ was considered statistically significant.

Results

Stroop test

The time of completion of each test, the number of mistakes, and difference between variant B and A (B-A – best represented cognitive functions in this test) were analyzed, separately for the whole group (with 2 attempts) and for those who completed 3 attempts. No statistically significant differences between the groups were observed. In each group, on Day 2 the results of variant A were worse than on Day 1. The results are shown in Tables 2, 3, and Figure 1A, 1B (showing the B-A result).

TMT

The time of completion of each test, the number of mistakes, and difference between variant B and A (B-A – best represented cognitive functions in this test) were analyzed, separately for the whole group (with 2 attempts) and for those who completed 3 attempts. No statistically significant differences between the groups were observed. In variant A, the time of completion on Day 2 was shorter in group A and longer in group B and C. However, the difference was not statistically significant. The comparison with the 3-day results and the comparison of the B-A results did not confirm this observation. The results are shown in Tables 4, 5, and Figure 1C, 1D (showing the B-A result).

VFT

The number of words given and mistakes made were registered for each attempt and then analyzed. No statistically significant differences were shown. In a number of categories (Fruits, Vegetables, and Animals, when 3 attempts were considered) an increase in the number of words given was noted in groups 1 and 2, while in group 3 the result remained constant or decreased. However, the difference was not statistically significant. The results are shown in Tables 6, 7.

Discussion

Anaesthesia has both short-term (reversible) and long-term impacts on the central nervous system. These changes result from the direct and indirect effects of anaesthetic drugs, but they are also related with the patient's initial condition, other drugs administered, and environmental factors (e.g., stress and elevated sympathetic activity), which are still under investigation.

There are 3 types of cognitive deterioration after surgery: delirium, short-term cognitive disturbance, and true POCD, which is a subtle deterioration in the cognitive function lasting weeks, months, or longer [34]. All of these cause increased incidence of complications influencing morbidity and mortality.

Recent studies show that applying PEEP does not influence the quality of the surgery field as long as the peak inspiratory pressure (PIP) is maintained below 15 cmH_2O [35]. In our study all the patients were maintained with PEEP 5 cmH_2O and PIP below 15 cmH_2O whenever possible.

The results of the Stroop test confirm that hypotension lasting about an hour does not influence the processing of interfering stimuli, even as soon as 3–4 hours postoperatively. The prolongation of the completion time of variant A on Day 2 and 3 was similar in each group and it was probably caused by the

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Table 2. Stroop's Test A and B results in each group – comparison of 2 attempts.

	N	Stroop A			Stroop B		
		Time 1	Time 2	p	Time 1	Time 2	p
Group 1 (MAP_{mn}/MAP0 >75%)	15	24.3±3.9	25.7±4.3	<0.05	63.6±12.3	58.3±17.6	0.17
Group 2 (65%< MAP_{mn}/MAP0 ≤75%)	19	24.3±5.7	28.0±6.3	<0.05	60.3±14.3	58.4±17.0	0.3
Group 3 (MAP_{mn}/MAP0 ≤65%)	13	23.5±4.3	26.6±3.9	<0.05	67.8±16.5	60.6±15.7	<0.05

N – number of patients; MAP_{mn}/MAP_0 – mean MAP during surgery to MAP day before surgery ratio; Time 1 – time of completion of the test on the day before the surgery; Time 2 – time of completion of the test on the day of the surgery; number of mistakes in each attempt did not differ statistically.

Table 3. Stroop's Test A and B results in each group – comparison of 3 attempts.

	N	Stroop A				Stroop B			
		Time 1	Time 2	Time 3	p	Time 1	Time 2	Time 3	p
Group 1 (MAP_{mn}/MAP0 >75%)	12	24.3±1.0	25.6±1.0	27.4±3.0	0.36	64.5±3.5	60.9±5.2	53.5±4.1	0.1
Group 2 (65%< MAP_{mn}/MAP0 ≤75%)	13	24.3±1.6	28.1±1.8	25.1±1.4		59.0±3.7	58.6±4.9	49.1±3.8	
Group 3 (MAP_{mn}/MAP0 ≤65%)	12	23.8±1.3	27.2±1.0	26.3±1.2		68.7±4.9	61.4±4.7	55.6±3.4	

N – number of patients; MAP_{mn}/MAP_0 – mean MAP during surgery to MAP day before surgery ratio; Time 1 – time of completion of the test on the day before the surgery; Time 2 – time of completion of the test on the day of the surgery; Time 3 – time of completion of the test on the day after the surgery; number of mistakes in each attempt did not differ statistically.

Table 4. Trail Making Test A and B results in each group – comparison of 2 attempts.

	N	TMT A			TMT B		
		Time 1	Time 2	p	Time 1	Time 2	p
Group 1 (MAP_{mn}/MAP0 >75%)	15	32.9±18.7	30.1±15.9	0.4	63.1±31.3	56.8±34.2	0.3
Group 2 (65%< MAP_{mn}/MAP0 ≤75%)	19	26.4±6.5	28.3±13.9	0.4	60.3±19.7	60.9±23.9	0.9
Group 3 (MAP_{mn}/MAP0 ≤65%)	13	28.6±10.9	30.5±13.8	0.5	69.5±48.8	66.7±48.6	0.9

N – number of patients; MAP_{mn}/MAP_0 – mean MAP during surgery to MAP day before surgery ratio; Time 1 – time of completion of the test on the day before the surgery; Time 2 – time of completion of the test on the day of the surgery; number of mistakes in each attempt did not differ statistically.

patients' discomfort due to the nasal pack inserted at the last phase of the surgery. However, Variant B was performed better every day, additionally reducing the B-A index. This shows that the learning effect, characteristic of the Stroop test at all ages, was also observed in all the groups after the surgery in controlled hypotension. This observation corresponds with the results of a study by Davidson, who showed a correlation between practice and Stroop test results [36]. This difference was best seen in those patients who had a third attempt.

The results of the TMT are difficult to interpret due to significant differences between the patients' results within each

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Table 5. Trail Making Test A and B results in each group – comparison of 3 attempts.

	N	Stroop A				Stroop B			
		Time 1	Time 2	Time 3	p	Time 1	Time 2	Time 3	p
Group 1 (MAP$_{mn}$/MAP0 >75%)	12	34.4±3.9	29.0±4.2	25.3±2.8	0.2	67.8±9.1	60.5±10.3	56.1±6.9	0.8
Group 2 (65%< MAP$_{mn}$/MAP0 ≤75%)	13	25.5±3.6	29.4±3.9	22.4±2.6		60.3±5.5	63.5±7.2	53.0±5.7	
Group 3 (MAP$_{mn}$/MAP0 ≤65%)	12	28.5±3.9	31.3±4.2	26.4±2.8		66.5±15.6	68.8±15.2	53.2±8.6	

N – number of patients; MAP$_{mn}$/MAP$_0$ – mean MAP during surgery to MAP day before surgery ratio; Time 1 – time of completion of the test on the day before the surgery; Time 2 – time of completion of the test on the day of the surgery; Time 3 – time of completion of the test on the day after the surgery; number of mistakes in each attempt did not differ statistically.

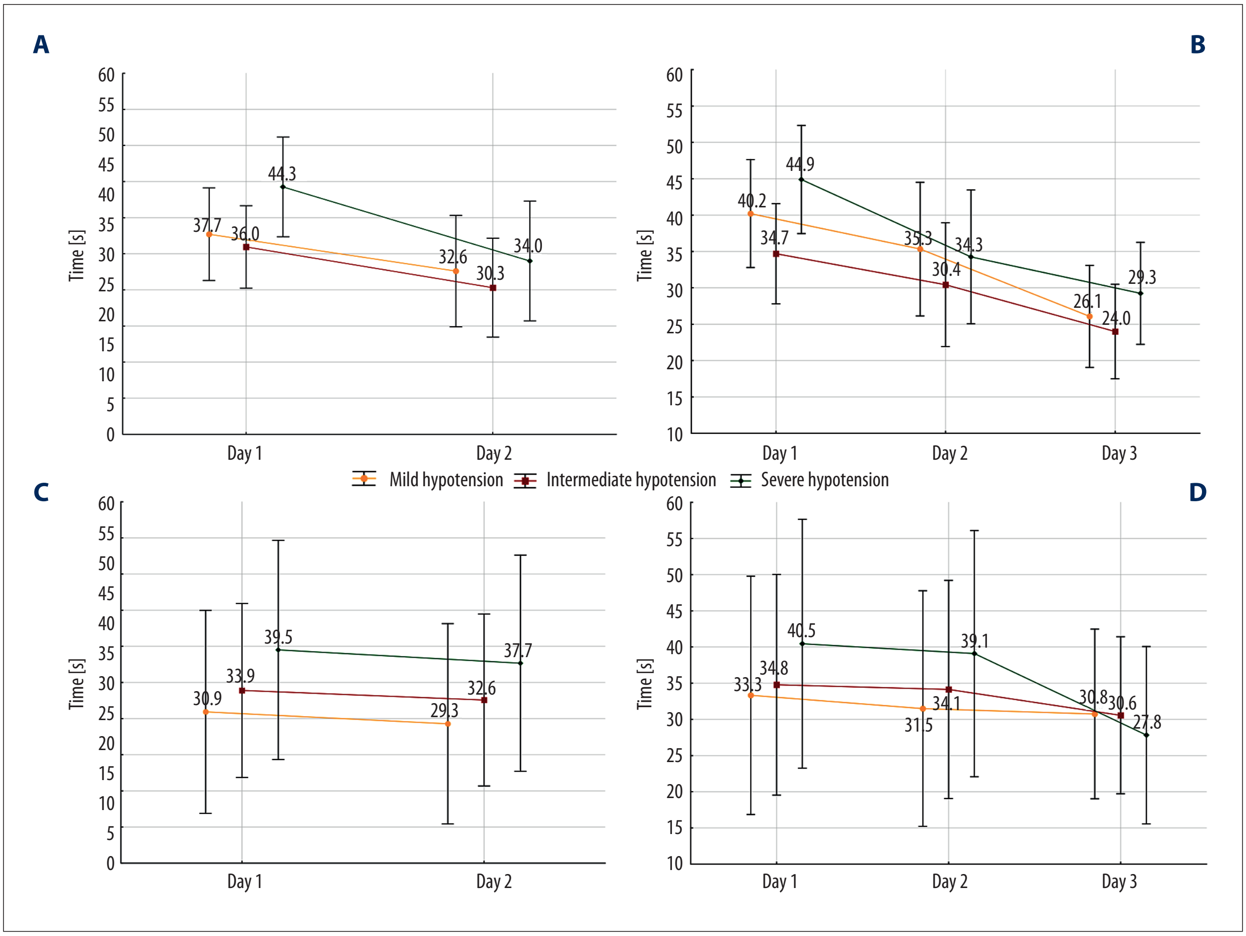

Figure 1. B-A results of tests. See text for further reference.

group, represented by high values of SD. Although the results suggested that the patients from groups 2 and 3 needed more time to complete the test on Day 2 and Day 3, the statistical value of this observation was limited. Another study proved the influence of age and education on the TMT results in a population of 911 individuals [37]. The groups in this study were too small to achieve statistical significance when they were divided into subgroups. Conducting the TMT in a larger population managed in controlled hypotension might provide new data regarding scanning, processing speed, and mental elasticity.

The VFT also showed the learning effect was maintained in all the groups. This effect was best seen in 2 categories (1 semantic category – 'vegetables' – and 1 phonemic category – 'L').

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Table 6. VFT results in 2 attempts; number of mistakes did not vary significantly between the groups.

Variant	Group	Day	Mean	SD	95% CI	p
Fruits	1	1	14.7	1.1	12.5–16.9	0.06
		2	15.3	1.1	13.1–17.5	
	2	1	15.8	1.0	13.9–17.7	
		2	18.2	1.0	16.2–20.1	
	3	1	16.5	1.2	14.1–18.8	
		2	15.5	1.2	13.1–17.8	
Animals	1	1	22.3	1.4	19.5–25.1	0.69
		2	22.9	1.5	19.8–26.0	
	2	1	24.0	1.2	21.5–26.5	
		2	25.6	1.4	22.8–28.3	
	3	1	21.0	1.5	17.9–23.9	
		2	21.5	1.7	18.2–24.9	
Vegetables	1	1	11.1	0.8	9.5–12.6	0.052
		2	13.5	0.8	11.9–15.2	
	2	1	12.9	0.7	11.5–14.3	
		2	13.9	0.7	12.4–15.3	
	3	1	13.1	0.8	11.4–14.8	
		2	12.8	0.9	11.0–14.6	
S	1	1	9.8	1.1	7.4–12.0	0.97
		2	10.0	1.1	7.8–12.2	
	2	1	13.4	1.0	11.4–15.5	
		2	13.3	1.0	11.4–15.3	
	3	1	9.5	1.2	7.0–11.9	
		2	9.5	1.2	7.1–11.8	
L	1	1	7.9	1.0	5.9–9.9	0.41
		2	10.4	1.0	8.4–12.4	
	2	1	11.4	0.9	9.6–13.2	
		2	12.5	0.9	10.7–14.2	
	3	1	8.8	1.1	6.7–11.0	
		2	9.6	1.1	7.5–11.8	
N	1	1	6.7	0.9	5.0–8.5	0.83
		2	7.3	1.1	5.1–9.4	
	2	1	9.2	0.8	7.6–10.8	
		2	9.9	0.9	8.0–11.8	
	3	1	7.3	0.9	5.4–9.2	
		2	7.3	1.1	5.0–9.6	

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Table 7. VFT results in 3 attempts; number of mistakes did not vary significantly between the groups.

Variant	Group	Day	Mean	SD	95% CI	P
Fruits	1	1	14.4	1.2	12.0–16.8	0.26
		2	15.0	1.3	12.4–17.6	
		3	15.8	1.1	13.6–17.9	
	2	1	17.3	1.1	15.0–19.5	
		2	18.9	1.2	16.5–21.3	
		3	18.3	1.0	16.3–20.3	
	3	1	16.6	1.2	14.1–19.1	
		2	14.8	1.3	12.1–17.5	
		3	15.8	1.1	13.5–18.0	
Animals	1	1	20.5	1.5	17.5–23.5	0.06
		2	21.2	1.6	17.9–24.5	
		3	24.8	1.8	21.1–28.4	
	2	1	24.1	1.4	21.4–26.9	
		2	25.5	1.5	22.5–28.5	
		3	27.2	1.7	23.8–30.6	
	3	1	21.5	1.6	18.4–24.7	
		2	22.1	1.7	18.7–25.5	
		3	21.7	1.9	17.9–25.5	
Vegetables	1	1	10.4	0.9	8.6–12.2	0.14
		2	13.3	0.9	11.5–15.2	
		3	12.8	0.9	10.9–14.6	
	2	1	13.5	0.8	11.9–15.1	
		2	13.9	0.9	12.2–15.7	
		3	14.9	0.8	13.1–16.6	
	3	1	13.3	0.9	11.4–15.1	
		2	13.1	1.0	11.1–15.0	
		3	13.5	0.9	11.6–15.5	
S	1	1	10.0	1.3	7.5–12.7	0.7
		2	9.8	1.2	7.3–12.2	
		3	10.4	1.3	7.8–13.0	
	2	1	14.5	1.8	12.1–16.9	
		2	14.7	1.1	12.4–17.0	
		3	15.9	1.2	13.4–18.3	
	3	1	8.9	1.3	6.2–11.6	
		2	9.0	1.3	6.4–11.6	
		3	11.6	1.3	8.9–14.4	

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Table 7 continued. VFT results in 3 attempts; number of mistakes did not vary significantly between the groups.

Variant	Group	Day	Mean	SD	95% CI	P
L	1	1	7.8	1.1	5.5–10.0	0.4
		2	9.9	1.1	7.6–12.2	
		3	10.5	1.2	8.0–13.0	
	2	1	12.0	1.0	10.0–14.2	
		2	13.1	1.1	11.0–15.3	
		3	13.6	1.1	11.3–15.9	
	3	1	8.9	1.2	6.6–11.3	
		2	9.1	1.2	6.7–11.5	
		3	8.8	1.3	6.1–11.3	
N	1	1	7.0	1.0	5.0–9.0	0.37
		2	6.7	1.2	4.3–9.0	
		3	7.8	1.2	5.2–10.3	
	2	1	9.6	0.9	7.8–11.5	
		2	11.0	1.1	8.8–13.2	
		3	12.4	1.1	10.1–14.8	
	3	1	7.3	1.0	5.2–9.4	
		2	7.0	1.2	4.5–9.5	
		3	8.8	1.3	6.2–11.5	

No complications in the functions of kidneys, lungs, nervous system, and cardiovascular system were observed. The time of anaesthesia and post-operative pain in the Numeral Rating Scale, which could have affected cognitive functions, did not differ significantly between the groups.

The study was limited by lack of feedback from the surgeons regarding visibility in the surgical field. Simultaneous evaluation of the vision quality (ideally assessed by the same surgeon) and cognitive function would be an interesting subject for further research.

Conclusions

The results of psychometric tests conducted on the patients undergoing FESS in controlled hypotension did not differ significantly between the groups. Controlled hypotension seems to be equally safe for the patient as anaesthetic management in normotension, simultaneously decreasing the complication rate.

Conflict of interest

The authors declare no conflict of interest.

References:

1. Boonmak S, Boonmak P, Laopaiboon M: Deliberate hypotension with propofol under anaesthesia for functional endoscopic sinus surgery (FESS). Cochrane Database Syst Rev, 2013; 6: CD006623
2. Drozdowski A, Sieskiewicz A, Siemiatkowski A: [Reduction of intraoperative bleeding during functional endoscopic sinus surgery]. Anaesthesiology Intensive Therapy, 2011, 1; 45–50 [in Polish]
3. Sieskiewicz A, Drozdrowski A, Rogowski M: The assessment of correlation between mean arterial pressure and intraoperative bleeding during endoscopic sinus surgery in patients with low heart rate.. Otolaryngol Pol, 2010; 64(4): 225–28 [in Polish]
4. Shirgoska B, Netkovski J, Zafirova B: The influence of remifentanil and remifentanil-plus-sevoflurane-controlled hypotension on mean arterial pressure And heart rate in children. Prilozi, 2012; 33(1): 171–85
5. Degoute CS: Controlled hypotension: a guide to drug choice. Drugs, 2007; 67(7): 1053–76
6. Coskun D, Celebi H, Karaca G, Karabiyk L: Remifentanil versus fentanyl compared in a target-controlled infusion of propofol anesthesia: quality of anesthesia and recovery profile. J Anesth, 2010; 24: 373–79
7. Eberhart LHJ, Kussin C, Arndt C et al: Effect of a balanced anaesthetic technique using desflurane and remifentanil on surgical conditions during microscopic and endoscopic sinus surgery. Rhinology, 2007; 45; 72–78

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[Chemical Abstracts/CAS] [Index Copernicus]

8. Cafiero T, Cavallo LM, Frangiosa A et al: Clinical comparison of remifentanil-sevoflurane *vs.* remifentanil-propofol for endoscopic endonasal transphenoidal surgery. Eur J Anaesthesiol, 2007; 24: 441–46
9. Goswami U, Babbar S, Tiwari S: Comparative evaluation of the effects of propofol and sevoflurane on cognitive function and memory in patients undergoing laparoscopic cholecystectomy: A randomised prospective study. Indian J Anaesth, 2015; 59(3): 150–55
10. Schoen J, Husemann L, Tiemeyer C et al: Cognitive function after sevoflurane-*vs.* propofol-based anaesthesia for on-pump cardiac surgery: a randomized controlled trial. Br J Anaesth, 2011; 106(6): 840–50
11. Finnerty FA, Witkin L, Fazekas JF: Cerebral hemodynamics during cerebral ischemia induced by acute hypotension. J Clin Invest, 1954; 33(9), 1227–32
12. Harmsen P, Kjaerulff J, Skinhoj E: Acute controlled hypotension and EEG in patients with hypertension and cerebrovascular disease. J Neurol Neurosurg Psychiatry 1971; 34(3), 300–7
13. Townes BD, Dikmen SS, Bledsoe SW et al: Neuropsychological changes in a young, healthy population after controlled hypotensive anesthesia. Anesth Analg, 1986; 65(9): 955–59
14. Moller JT, Cluitmans P, Rasmussen LS et al: Long-term postoperative cognitive dysfunction in the elderly ISPOCD1 study. ISPOCD investigators. International Study of Post-Operative Cognitive Dysfunction. Lancet, 1998; 351(9106): 857–61 [erratum, Lancet, 1998; 351(9117): 1742]
15. Borkowska A: Znaczenie zaburzeń funkcji poznawczych i możliwości ich oceny w chorobach psychicznych. Psychiatria w Praktyce Klinicznej, 2009; 2(1): 30–40 [in Polish]
16. Borkowska A Rybakowski J: Wpływ preparatu olanzapiny (Zolafren) na funkcje poznawcze w schizofrenii. Farmakoterapia w Psychiatrii i Neurologii, 2005; 4: 389–95 [in Polish]
17. Borkowska A, Sobów T: [Neuropsychological assessment in the diagnosis and differential diagnosis of fronto-temporal dementia]. Neurologia i Neurochirurgia Polska, 2005; 39(6): 466–75 [in Polish]
18. Borkowska A. Pamięć operacyjna i jej zaburzenia w chorobach psychicznych. Przew Lek, 2003; 6(3): 86–91 [in Polish]
19. Coburn M: Postoperative cognitive dysfunction: Incidence and prophylaxis. Anaesthesist, 2010; 59: 177–85
20. Domańska Ł, Borkowska AR: Podstawy neuropsychologii klinicznej, 2009 Wydawnictwo UMCS [in Polish]
21. Hanning CD, Kuipers HM, Jolles J et al: International Study of Postoperative Cognitive Dysfunction ISPOCD 2-study. Acta Anaesthesiol Scand, 2003; 47(3): 260–66
22. Koch G, Costa A, Brusa L et al: Impaired reproduction of second but not millisecond time intervals in Parkinson's disease. Neuropsychologia, 2008; 46: 1305–13
23. Mosiołek A, Łoza B: Co mierzą testy neurokognitywne w schizofrenii? Psychiatria, 1(2): 113–19 [in Polish]
24. Nathan J, Wilkinson D, Stammers S, Low JL: The role of tests of frontal executive function in the detection on mild dementia. Int J Geriatr Psychiatry, 2001; 16: 18–26
25. Tomaszewska M, Markowska A, Borkowska A: Test Stroopa – wartość diagnostyczna w psychiatrii. Neuropsychiatria i Neuropsychologia, 2010; 5(1): 35–41 [in Polish]
26. Johnson T, Monk T, Rasmussen LS et al: Postoperative cognitive dysfunction in middleaged patients. Anesthesiology, 2002; 96: 1351–57
27. Rabbitt P: Long-term postoperative cognitive dysfunction in the elderly ISPOCD1 study. Lancet, 1998; 351: 857–61
28. Wysokiński A, Zboralski K, Orzechowska A et al: Normalization of the Verbal Fluency Test on the basis of results for healthy subjects, patients with schizophrenia, patients with organic lesions of the chronic nervous system and patients with type 1 and 2 diabetes. Arch Med Sci, 2010; 6(3): 438–46
29. Piskunowicz M, Bieliński M, Zgliński A, Borkowska A: [Verbal fluency tests – application in neuropsychological assessment]. Psychiatria Polska, 2013; XLVII(3): 475–85 [in Polish]
30. Keilp JG, Gorlyn M, Alexander GE et al: Cerebral blood flow patterns underlying the differential impairment in category *vs.* letter fluency in Alzheimer's disease. Neuropsychologia, 1999; 37: 11
31. Shim YS, Youn YC, Na DL et al: Effects of medial temporal atrophy and white matter hyperintensities on the cognitive functions in patients with Alzheimer's disease. Eur Neurol, 2011; 66: 75–82
32. Rasmussen L, Stygall J, Stanton PN: Miller's Anesthesia. Cognitive dysfunction and other long-term complications of surgery and anesthesia. 7th ed. Philadelphia: Churchill Livingstone Elsevier, 2010; Ch. 89; 2805–19.
33. DeMaria S, Govindaraj S, Huang A et al: The influence of positive end-expiratory pressure on surgical field conditions during functional endoscopic sinus surgery. Anesth Analg, 2015; 120(2): 305–10
34. Davidson DJ, Zacks RT, Williams CC: Stroop interference, practice, and aging. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn, 2003; 10(2): 85–98
35. Tombaugh TN: Trail Making Test A and B: normative data stratified by age and education. Arch Clin Neuropsychol, 2004; 19: 203–14

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