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# Assessment of selected cognitive processes in elderly patients after urologic surgery

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ABSTRACT

*Introduction:* The issue of postoperative disorders of cognitive functions is a highly topical problem as more and more elderly people undergo medical treatments. Patients may lose the ability of assimilating information and their linguistic functions may deteriorate. Cognitive disorders may result in the temporary exclusion of the patient from social activity.
*Aim:* The purpose of the paper was to assess the incidence of certain cognitive disorders in the elderly after urological surgeries.
*Material and methods:* The study was conducted in a group of 218 patients aged over 65, male and female, after an urological surgery under different types of anesthesia. Standardized neuropsychological tests of cognitive functions were employed in the study.
*Results:* Analysis of the data showed that in the control group were obtained similar results in the study of the first and second. However, in the test group demonstrated a reduction cognitive function in all the tests in a second study.
*Conclusions:* The reduction of cognitive functions in the study group was observed in all the domains but it was the most marked in visual memory tests. Postoperative reduction of cognitive functions is correlated with the patient's age, education and mood. Postoperative reduction of cognitive functions is not correlated with the type of surgery, anesthesia and its duration.



## 1. Introduction

The elderly population is constantly increasing as a consequence of healthier lifestyle, advancements in medicine and demographic factors [1,2]. Together with the growing elderly population there are more and more health problems typical of the age group. Current studies show that the analyzed group is highly diversified. Not everyone ages in the same way. The assessment of the aging process of an elderly person should take into account, apart from calendar age which only slightly determines the person's mental and physical ability, their

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biological age, mental condition and social status, remembering however that these factors interact [3,4].

In elderly patients the impairment of the central nervous system depends on involutional changes and is significantly affected by insufficient blood flow to the brain. These changes lead to an impairment of memory and concentration. There are a large number of potentially reversible or transitory disorders of memory and other cognitive functions. Their causes are diverse and often complex, including renal insufficiency, diabetes, cerebral strokes, geriatric iatrogenic syndrome and hospitalizations [5,6].

Postoperative disorders of cognitive functions have been classified as a separate syndrome. Advancements in surgical and anesthesiological techniques have reduced the number of complications and mortality among patients undergoing surgical treatment. Nevertheless, postoperative disorders of cognitive functions remain a serious problem. Cognitive disorders lead to prolonged hospitalization, they generate higher costs and negatively affect the quality of life. Cognitive disorders can cause the patient's temporary exclusion from social activity, making him dependent on the help and care of others [3,5,6].

The purpose of the paper was to assess the incidence of certain early disorders of cognitive functions in the elderly undergoing urological surgeries.

An attempt has been made to answer the following questions:

1. What factors affected the reduction of cognitive functions in the study group?
2. What is the relationship between cognitive function disorders and the type of anesthesia, type of surgery, duration of anesthesia, age and education?

## 2. Material and methods

### 2.1. *Patient population*

The study was conducted upon approval of the study protocol by the Independent Ethics Committee for Scientific Research. The studies lasted three years. 244 subjects were invited to the study and 188 completed it. All the subjects were patients of the Urology Clinic.

**The inclusion criteria were:** patients aged 65 and over, male or female, qualified for urological surgeries and who gave their consent for the assessment, without dementia in screening tests of cognitive function, with no evidence of depression in screening tests, with no drug and alcohol addiction; assessed according to the scale of anesthesia-related risk of the American Society of Anesthesiologists as ASA I, II, III, anesthetized without limitations as to the method applied.

**The exclusion criteria were:** patients who scored 23 or less in the MMSE, on anti-depressing and sedative medications, patients who underwent neuropsychological tests 1–2 years ago, those who did not give their consent, who do not understand the language spoken, suffering from serious hearing or sight impairment, illiterate patients, patients with Parkinson's disease, abusing alcohol or addicted to drugs.

### 2.2. *Neuropsychological tests*

The following standardized neuropsychological tests of cognitive functions were used to assess the patients.

**For the global assessment of cognitive functions:**

*Mini-Mental State Examination (MMSE)* – a global assessment of cognitive functions. MMSE is a simple tool used to assess the basic dimensions of cognitive activity. During the examination the patient is asked a number of questions concerning the sense of space and time. Further tasks are related to: memorizing, attention, calculating, recalling, concentration, reproduction of previously memorized information, naming, reading, writing and carrying out complex orders. Points are awarded for each correct answer: 30–28 points for the norm, 27–24 points for minor cognitive disorders, according to the diagnostic criteria, a score below 24 points on the MMSE scale suggests the dementia syndrome [7–9].

**For the assessment of short-term memory:**

*Auditory Verbal Learning Test – AVLT* – measures the upper limit of immediate memory, reveals the learning curve or its lack, showing tendencies to retro- and proactive interference and a tendency to confusion and confabulation in memory tasks. It also measures the preservation of memorized information after another overlapping activity. It is a verbal learning test used to assess short-term memory and verbal learning ability. A list of fifteen semantically unrelated words was read five times in succession. The patient repeated the words heard five times in succession. The number of words repeated for the first time was an indicator of learning ability. The total number of words repeated in the subsequent turns was considered a gauge of learning ability. Subsequently, a short story was read to the patient who was asked to recognize the words from the previously read list of fifteen words in it [10,11].

*Wechsler's Memory Span (WAIS)* – a subtest of "digit repetition" is used to assess short-term auditory memory. The investigator reads out increasing digit sequences starting from a single digit and the subject repeats them immediately afterwards, forwards and backwards. The test was interrupted after two false repetitions of a sequence of the same number of digits [10].

*Visual Memory Test (the so-called Brain Damage Diagnosing Test, BDD)* – the test evaluates spatial learning and memory on figural material. According to the test's accuracy studies, the BDD test can be assumed to comprise the following functions:

- concentration,
- perception of figures,
- immediate memory of figures,
- ability to recall figures and transfer this ability onto the motor plane.

The test material consisted of 9 white cards. A figure of 5 black lines was drawn on each card. The subject's task was to remember a series of figures and recall them from memory using sticks. No time limit was applied. If the subject correctly completed all the 9 figures during the recall test, the test could be finished [12].

*Geometric Pattern Memory Test (Benton)* – measures immediate visual memory; a variant of the visual memory test. The subject is given blank pieces of paper with dimensions similar to those of the cards with geometric patterns. The subject is consecutively shown 10 cards with geometric patterns. The subject looks at each geometric pattern for 10 s and after the card with the pattern is taken away s/he must recall the geometric patterns from memory. The subject may not rub out or correct drawings. If the subject asks whether the drawing is correct, s/he can be assured of its correctness [13].

*Trail Making Test – TMT, versions A and B* – a test measuring visual and motor coordination and working memory. The trail making test requires immediate recognition of the symbolic meaning of digits and letters, an ability to continually scan the whole sheet to find the next digit or letter in the sequence, flexibility in assembling digit and letter sequences and compliance with these requirements under time pressure. It is composed of two parts: A and B. In part A, 25 circles numbered 1–25 are scattered on a white sheet of paper. The subject is required to connect the circles by drawing a continuous line in pencil, as fast as possible. Starting with circle no. 1 s/he moves on to the circle with the subsequent number. In part B of the sheet there are 25 circles marked with numbers 1–13 and letters A–L. The subject is expected to connect the circles, passing from digits to letters alternately and following the increasing order of both sequences (of digits and letters). Time (in seconds) needed for each part of the test is recorded [14].

**For the assessment of mood:**

*Beck's Questionnaire* – was employed to assess the patient's mood to exclude the effect of severe depression on cognitive functions. The questionnaire enables self-evaluation of the severity of depression and consists of 21 groups of statements, with scores of 0–3. By evaluating the statements, the patient defines his/her psychophysical condition in the month preceding the test. Scale assessment: 0–11 no depression, 12–26 mild depression, 27–49 moderate depression, and 50–63 severe depression [10,15].

The above tests were conducted and assessed in cooperation with a psychologist. The study was divided into two sessions and took 2–3 h.

In the pre-operative period – the original version, and during the repeat study – the substitute version.

The tests were conducted in a quiet and peaceful place, always before noon and in the same room. It was necessary to state the frequency and the reason for refusal to take part in the repeat test.

After establishing contact with the patient and qualifying him/her for the study, the study information and informed consent form were handed to the patient. The tests were preceded by a medical interview about the patient's health.

The patients were subdivided into two groups:

Group I – the control group – hospitalized patients during diagnostics or waiting for surgery.

Group II – the study group whose members were given the following types of anesthesia: composite intravenous anesthesia (thiopental 2–5 mg/kg BW, vecuronium 0.1 mg/kg BW, phentalnyl 0.05–0.1 mg), conduction anesthesia (marcaina heavy spinally 0.5%, midazolam 0.05–0.1 mg/kg BW), combined anesthesia (general + regional).

The patients were normally premedicated with midazolam 0.05–0.2 mg/kg BW.

All the patients were assessed by means of cognitive function tests; the control group on the second day following admission and on the seventh day of hospitalization. The study group was assessed two days before the surgery and on the seventh day following the surgery.

### 2.3. *Statistical analysis*

The statistical analysis comprised tests of differences between means. A comparison was performed between the outcome of the first (pre-surgery) and second (post-surgery) measurement of cognitive functions and mood. Interactions were evaluated by means of ANOVA test in a mixed $2 \times 2$ model and their direction was described using a *t*-test. Correlations between variables were evaluated by means of *r*-Pearson's coefficient for normally distributed data. $p < 0.05$ was considered statistically significant.

Regression analysis was also performed to define correlations between perioperative factors affecting cognitive functions. Calculations were performed using SPSS 12.0 software.

## 3. Results

### 3.1. *Respondent characteristics*

A total of 218 patients were evaluated. The control group consisted of 30 patients: 8 (26.67%) women and 22 (73.33%) men. The study group consisted of 188 patients: 67 (35.63%) women and 121 (64.36%) men. Both groups did not differ statistically with respect to sex, age and type of procedure. The mean age of the patients in the control group was 70.83 years (SD ± 5.83). The mean age of the patients in the study group was 71.51 years (SD ± 5.56). The length of education in the control group was 11.96 years (SD ± 3.39) whereas in the study group it was 11.64 years (SD ± 2.38). Characteristics of patients are given in Table 1.

There were 15 (7.97%) ASA physical status I patients, 110 (58.51%) ASA physical status II and 63 (33.51%) ASA physical

**Table 1 – Socio-demographic characteristics of patients.**

| | Group | |
|---|---|---|
| | Control | Studied |
| Sex | | |
| Femal | 8 (26.67%) | 67 (35.63%) |
| Male | 22 (73.33%) | 121 (64.36%) |
| Age | | |
| 65–70 | 25 (83.33%) | 94 (50%) |
| 71–75 | 4 (13.33%) | 82 (43.61%) |
| 76–80 | 1 (3.33%) | 12 (6.38%) |
| Education | | |
| Primary school | 0 (0%) | 6 (3.19%) |
| Trade school | 15 (50%) | 109 (57.98%) |
| College | 13 (43.33%) | 62 (32.97%) |
| Higher | 2 (6.66%) | 11 (5.86%) |
| Total | 30 (100%) | 188 (100%) |

**Table 2 – Type of procedure.**

| Type of procedure | N |
|---|---|
| Nephrectomy | 30 (16%) |
| Cystectomy | 27 (14.4%) |
| Prostatectomy | 14 (7.4%) |
| Transurethral resection of the prostate | 45 (23.9%) |
| Transurethral resection of the tumor | 54 (28.7%) |
| Ureteronephroscopy | 8 (4.3%) |
| Percutaneous nephrolithotomy | 7 (3.7%) |
| Orchidectomy | 3 (1.6%) |
| Total | 188 (100) |

**Table 3 – Duration of anesthesia.**

| Time in minutes | N |
|---|---|
| 0–30 | 12 (6.4%) |
| 35–60 | 32 (17.0%) |
| 65–90 | 45 (23.9%) |
| 95–120 | 28 (14.9%) |
| 125–150 | 16 (8.5%) |
| 155–180 | 12 (6.4%) |
| 185–210 | 13 (6.9%) |
| 215–240 | 12 (6.4%) |
| 145–270 | 10 (5.3%) |
| Longer than 270 | 8 (4.3%) |
| Total | 188 (100%) |

status III patients. ASA physical status was assessed only in patients that underwent surgery. The type and number of procedures are given in Table 2.

There were 92 (48.95%) general anesthetics, 82 (43.61%) procedures under regional anesthesia, and in 14 (7.44%) patients combined technique was employed (general and regional anesthesia). The duration of anesthesia was 101.8 min (SD ± 34.37) (Table 3).

## 3.2. *Assessment of cognitive functions in studied groups*

### 3.2.1. *Assessment of cognitive functions with MMSE test*

The analysis indicates that the older the patient the greater the disturbances of cognitive processes evaluated with MMSE test, $r = -0.377$, $p = 0.000$. It was further demonstrated that the more educated the patient the lesser the disturbances of cognitive processes measured with MMSE test $r = 0.166$, $p < 0.023$.

### 3.2.2. *Assessment of the short-term memory with AVLT test*

The evaluated groups lost their memorizing abilities by losing the verbal material, however, an analysis of the decreases in both groups and their comparison showed that they were mostly similar. Statistically significant differences between the groups were observed in the recognition test $F(1) = 13.015$, $p = 0.000$, in the loss of material after 10 min $F(1) = 4.187$, $p < 0.042$ as well as differences in the outcomes of the sum of the reproduction series $F(1) = 4.744$, $p < 0.031$ (Graph 1).

### 3.2.3. *Assessment of the short-term auditory memory with Wechsler's test*

An analysis of short-term auditory memory evaluation by means of Wechsler's test demonstrates that the total number of digits correctly repeated forwards and backwards was similar in the evaluated groups and it did not differ significantly.

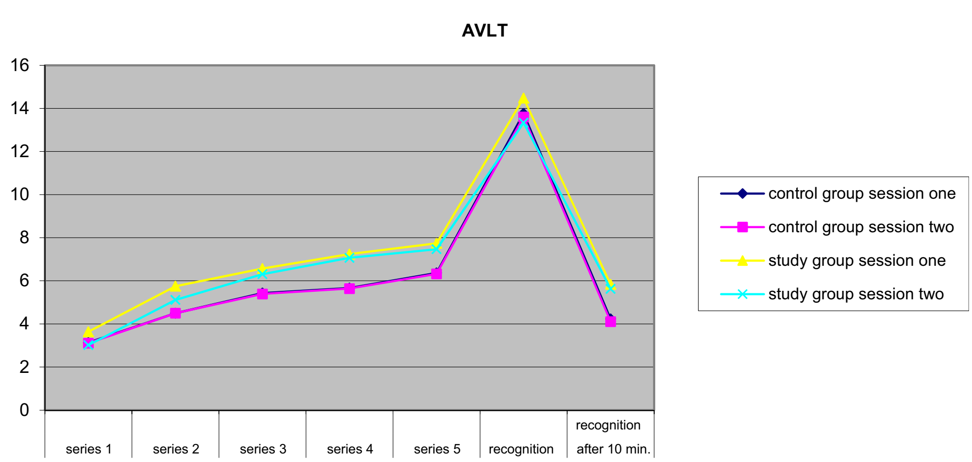
### 3.2.4. *Assessment of visual memory with visual memory test (BDD)*

Graph 2 shows that in the control group the result on the BDD scale has remained approximately constant in both tests, while in the study group it has deteriorated after the surgery (the higher the result the greater the loss of material after 10 min) $t(216) = 2.438$, $p < 0.05$. There is a significant interaction between the patient's anesthesia and the score achieved on the BDD scale $F(1) = 5.098$, $p < 0.05$.

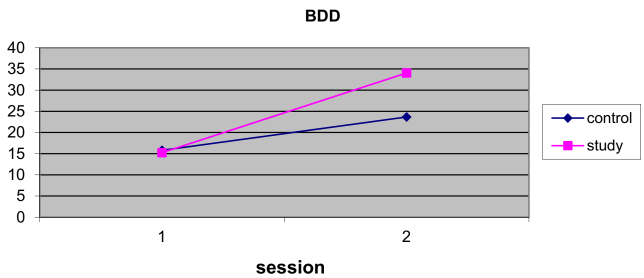
### 3.2.5. *Assessment of visual memory with Benton test*

Graph 3 illustrates that in the control group the result on the Benton scale was approximately constant in both tests, and in the study group it deteriorated after the procedure. The direction of the change was toward the "control" meaning that initially the study group achieved better results than the control group $t(216) = 4.173$, $p < 0.001$, and after the procedure the difference was no longer present.

There is significant interaction between the patient's anesthesia and the score achieved on the Benton scale $F(1) = 11.424$, $p < 0.05$.




**Graph 1 – The lost of verbal material (AVLT test) in consecutive series in three groups.**




**Graph 2 – The lost of visuospatila memory (BDD test) – comparison of groups.**

### 3.2.6. *Assessment of the psychomotor speed and working memory*

The results of TMT A test, designed mostly to assess the psychomotor speed, demonstrated that the scores in the study group were lower than those obtained by the control group in the second test. Statistically significant differences between the groups in TMT A test were observed: $F(1) = 11.114$, $p > 0.001$.

In the TMT B test, which involved working memory, the score was also lowered in the study group in the second test and no statistically significant differences were found between groups.

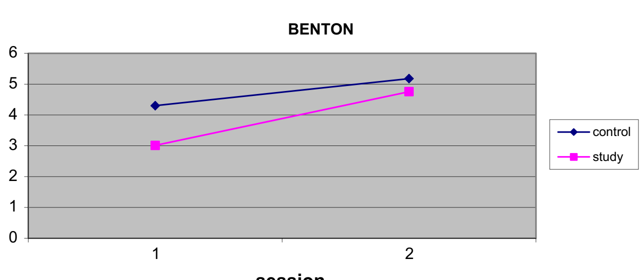
The evaluation of visual and motor coordination was performed on the basis of the difference between test B and A scores in both groups. An analysis of the score showed that the study group scored less in the second test after the surgical procedure in comparison to the control group without statistically significant differences between the groups.

### 3.2.7. *Assessment of the patients' mood with Beck's test*

An analysis of Beck's questionnaire in the groups leads to the conclusion that the first measurement in the control group showed that in 14 (46.66%) out of 30 patients no depression was found, 15 (50%) suffered from mild depression and 1 (3.33) had moderate depression.

In the study group, no depression was found in 158 (84.04%) out of 188 patients, 28 (14.89%) suffered from mild depression and 2 (1.07%) had moderate depression. Severe depression was found neither in the study nor in the control group.

The second measurement demonstrated that in the control group no depression was found in 6 (20%) out of 30 patients, in 23 (76.67%) mild depression was diagnosed and 1 (3.33%) had moderate depression. In the study group, no depression was found in 164 (87.23) out of 188 patients, in 22 (11.70%) mild depression was diagnosed and 2 (1.07%) had moderate depression. Severe depression was found neither in the study nor in the control group. Patients with depressed mood scored less in memory tests after the surgical procedure (for AVLT test $r = -0.149$, $p < 0.042$, for BDD test $r = -0.156$, $p < 0.033$). The analysis demonstrates that the control group scored slightly less in comparison with the study group in the second measurement.




**Graph 3 – Assessment of visual memory with Benton test – comparison of groups.**

## 3.3. *Demographic variables and cognitive functions*

No statistically significant effect of the duration of anesthesia and type of surgical procedure on the decrease of cognitive functions after the surgical procedure was demonstrated.

Age negatively correlates with memory, which means that the older the person the greater the loss of the memorized material (for WAIS test $r = -0.452$, $p = 0.000$) after the surgical procedure.

Education negatively correlates with memory, which means that the less educated the patient the greater the loss of the memorized material (for AVLT test $r = -0.173$, $p < 0.018$, for BDD test $r = -0.181$, $p < 0.01$, for Benton test $r = -0.223$, $p < 0.003$) after the surgical procedure.

# 4. Discussion

The pathophysiology of postoperative cognitive dysfunction (POCD) is hardly known and there is presently no strategy of its prevention [16,17]. The investigations of POCD after non-cardiosurgical procedures are still in the initial stage and some of them are descriptive [18].

Making comparisons between works estimating the incidence of POCD is difficult. In the existing studies there are significant differences in both the assessment methods used (there is a considerable variability among patients, the studies regard diverse procedures, different types of anesthesia and statistical methods are used) [19–31] and the definition of POCD [32–34]. Despite such a diversity of perspectives and ideas, the previous studies in large groups after general and regional anesthesia with different medications (nitrous oxide, sevofluran, spinal bupivocaine and lignocaine) clearly suggest that cognitive deficit and intellectual impairment occur more frequently in the first week following surgery [4,10,18,35,36].

The studies conducted six months after surgery or later did not demonstrate impairment in cognitive functioning in most of the patients and they even showed an improvement. The studies conducted 1–2 years following surgery did not show statistically significant differences between groups, although some of them estimate that 1–2 years after surgery 1% of the subjects demonstrate cognitive decreases [18,37].

The present work employs memory and learning tests to show whether cognitive functioning is impaired after surgery. There is no single test measuring cognitive functions. 70 tests and 9 test batteries for cognitive functioning evaluation have been found in literature. The tests differ with respect to sensitivity, specificity, repeatability and learning effect. The most frequently assessed functions were memory and learning [16]. The test of declarative memory most commonly used in clinical studies in Poland is AVLT Rey's test [10,11,38]. The analysis of own studies shows that cognitive functioning decrease occurred across all the domains but most of all in visual memory tests. Declarative memory tests in patients in the postoperative group demonstrate that no impairments were observed in the tests whereby the criterion is the mere recognition of the material. As regards material reproduction, the results were worse than in the control group. The work has demonstrated a correlation between the surgical procedure and the results obtained in the BDD and Benton tests, which may suggest the proper selection of tests of cognitive disorders. According to the test results described by other authors, cognitive deficit can also occur in tests assessing concentration (Lester Digit Coding Test) and verbal working memory (Stroop's test) [39].

In the present study, the test used to globally assess cognitive functioning was the MMSE test. The analysis indicates that cognitive processes slightly decreased in the study group but the differences were not statistically significant. In the authors' opinion, the MMSE is useful for detecting obvious dementia but is not sensitive and specific enough to detect milder, selective or certain cognitive disorders [8,16,26,28,40].

Mentally active patients who have experienced a mild cognitive deficit and patients with a local as opposed to global deficit can achieve high scores at MMSE [8,16,38,40,41]. Own studies have demonstrated that the more educated the respondents were, the less they suffered from cognitive disorders.

Recently, the so-called Mild Cognitive Impairment, MCI, has been identified. The term is used to define slight cognitive disorders, usually affecting memory [23,31]. They are in the transitory zone between the physiological aging process and progressive demential diseases. Unfortunately, patients with MCI have not been adequately identified in the works concerning POCD. Hence, there is no information on the effects of anesthesia and surgery on this subgroup of patients who may be at a higher risk of cognitive disorders [23]. The authors are not unanimous about the components of the cognitive deficit associated with POCD nor about the degree of clinically significant dysfunction. Every acute illness demanding hospitalization can be associated with cognitive decrease which can imply that cognitive decrease can result from the disease itself, not the surgery or anesthesia. The reasoning according to which patients with MCI should be more exposed to POCD springs from the concept of ''cognitive reserve'' meaning that the brain can (structurally and functionally) buffer a certain neuropathology and only after the reserve is expended do detectable disorders appear. In patients with MCI the reserve is at least impaired; this hypothesis can also explain the protective impact of the level of education on POCD incidence – the longer the education lasts, the greater the reserve and the stronger ''insult'' is required to induce measurable disorders [15,22,38,42]. There is a group of patients who manifest long-lasting severe disorders following surgery and anesthesia. Further study of this group of MCI patients will be required to be able to understand the risk of cognitive dysfunction following non-cardiological surgery [28,29,34,42–47].

Own research indicates that the level of education is in inverse proportion to memorizing capacity (the lower the education level the greater the loss of acquired material). Such authors as Rasmussen, Rodriguez, Albildstam and Jackson have assessed the effects of education and intelligence on postoperative cognitive decrease. The decrease was, however, small [3,4,48–50]. Rasmussen has shown that in less educated patients POCD was more pronounced [3].

POCD etiology remains unclear; various hypotheses have been proposed, suggesting for instance cerebrovascular disorders, brain hyperperfusion, neurotransmitter function disturbances, inflammatory changes in the central nervous system and genetic susceptibility but general anesthesia has aroused the strongest suspicion. Intuitively, it would seem that general anesthesia which directly affects the brain and regional anesthesia affecting primarily the spinal cord and peripheral nerves should be associated with different incidence of POCD. Yet, a number of studies suggest that the choice of anesthesia is not a significant factor in POCD development [17,42,43].

In early 1980s the findings from several small studies indicated that general anesthesia led to a higher risk of cognitive decrease than regional anesthesia did [32].

Only in 1995 Rasmussen conducted a prospective randomized study comparing the incidence of cognitive disorders following general and regional anesthesia. In the study, no statistically significant differences were observed on the seventh day and six months following surgery [3,51]. No statistically significant differences between the effect of general anesthesia and regional anesthesia on postoperative cognitive decrease were found in the study either.

Although in clinical studies these radically different techniques of anesthesia have a similar effect on cognitive decrease, there are laboratory tests suggesting that agents used for general anesthesia have a toxic effect on CNS structure and function. Long-lasting changes in the CNS or potentially relating to the CNS due to anesthetic agents are associated with increased beta oligomerization of proteins following exposure to inhalation anesthetics for general anesthesia and increased cytotoxicity of oligomers in the presence of inhalation anesthetics. Short exposure to desflurane induces changes in protein expression in the brain, the latter lasting much longer than the mere presence of the medication.

In the developing brain anesthetics induce neuronal degeneration. Anesthetics are capable of activating both exogenous and endogenous apoptosis. Anesthesia in newborn babies has a measurable impact on learning in adulthood [23].

Regional anesthesia has no effect on POCD reduction. The choice of anesthesia is of no significance for cognitive decrease [22]. Rasmussen, in a randomized study of a large study group, demonstrated that early cognitive decrease was less pronounced in patients given regional anesthesia than those given general one but three months later it was observed that all differences had disappeared [32,51].

Thus the data obtained so far disprove the correlation between the type of anesthesia and cognitive decrease [40]. The present work has not demonstrated statistically significant differences between the type of anesthesia and cognitive decrease.

The extent of surgical procedure can be a significant cause of postoperative cognitive disorders. Rasmussen's work, comparing 164 patients who underwent surgery under general anesthesia and spent at least 1 night in hospital with 159 patients who underwent surgery under general anesthesia performed as one-day surgery, showed that one-day surgery did not lead to significant cognitive decrease. As regards extensive surgical procedures and cognitive disorders in the first week, the latter were evidently associated with increasing age, duration of surgery, subsequent surgery, postoperative infections, respiratory disorders and lower level of the patient's education. After three months age became a significant factor [52].

An interesting experiment was conducted on rats by Wan et al. A group of rats was anesthetized and subjected to splenectomy while the other group of rats was only anesthetized without surgery. It was found that the rats that had been operated on demonstrated certain cognitive disorders for a short time following surgery. Those that had been anesthetized only demonstrated no such disorders, which suggests that the anesthesia per se was not the cause of the changes observed [9].

It appears that the question that requires explanation and further study is whether pain or certain types of medications (i.e. benzodiazepines, dopamine antagonists, alpha-2 antagonists, alpha-1 antagonists, phenytoine, phenobarbital) administered postoperatively can cause lower scores in neuropsychological tests [43]. It is possible that these medications and pain are the reason why POCD incidence is the highest in the first post-surgery week [21,23,35,37,41,43]. In one of the studies lower scores were obtained in tests measuring speed in the first week after surgery and the authors suggest that this may have been due to analgesia, staying in bed, restricted diet, disturbances in sleep availability and postoperative pain. Both groups improved after three months whereas operated patients showed greater progress in sensomotor tests and lower improvement in tests of general information processing [32,35,43].

Rassmusen showed that the presence of postoperative pain is associated with lower scores in neuropsychological tests; he examined 24 patients aged 61–86 who had undergone lumbar spine surgeries – greater intensity of pain in the first day after surgery was associated with lower scores in some neuropsychological tests [51].

Other authors have suggested in their studies that hypoxemia and ischemia are potential causes of POCD and they can be treated with, for example, oxygen therapy. The first works devoted to POCD incidence examined their significance as potential causes of cognitive decrease. Despite the high incidence of deep hypoxemia and hypotension, no relationship between these events and POCD was shown [3,4,22].

An important factor, which is likely to affect the results of cognitive testing, is depression. In certain studies depression negatively correlates with the results of neuropsychological tests [52]. In the studies discussed the thesis was confirmed – patients with depressed mood achieved lower scores in memory tests. Surprisingly, the control group achieved slightly lower scores in comparison to the experimental group in the second test, which was most probably related to a longer waiting period before surgery and the examinations performed.

An interesting observation made in the studies concerns the appearance of subjective feelings in the patients examined. It turned out that patients in both groups complained of memory deterioration both in the first and second study, where these feelings grew slightly more intense following surgery (mostly related to sleeping problems).

Previous studies had rarely made comparisons between patients' feelings and objective results of psychological tests [18]. One of the studies assessed the mood of patients complaining of cognitive decrease which was not objectively confirmed in the tests performed. The patients suffered from more severe depression and higher degree of anxiety.

As regards long-lasting cognitive disorders, although no cognitive dysfunctions were detected by means of neuropsychological tests after 6 months, 17% of patients reported subjective memory deterioration. A surgery can trigger a number of psychological effects such as mild depression or realization of age-related changes and lead to the development of these subjective feelings. Such feelings can also be triggered by the experience of unexpected POCD immediately following surgery, which can be worrying for the patients and make them lodge complaints. From this aspect medical, psychological and neuropsychological interventions may prove significant – for example, patients should be informed what to expect after surgery. Other authors such as Jakson and Rasmussen noted that patients who knew more about the approaching surgery worried less and regained their health sooner, which can affect the number of patients reporting subjective deterioration of cognitive functions [49,52].

The next thesis explaining the presence of subjective feelings which were not confirmed in neuropsychological tests is the short period of testing. Patients are able to summon up and use ''cognitive reserves'' but are not able to keep up the motivation for longer, which results in cognitive impairment in everyday life and leads to complaints about POCD [18].

The statement that once cognitive decrease is identified, causal treatment is not possible seems untrue. Therapy is aimed at early diagnosis and early use of safety measures, assistance in daily activities and education of the patient and his family [43].

The findings presented in this paper are preliminary and the study group is relatively small. Further studies in larger groups of patients are undoubtedly necessary. The results obtained point to relatively minor changes which may be essential to the education process too.

## 5. Conclusions

The following conclusions can be drawn on the basis of the data collected:

Cognitive decrease in the study group was observed in all the domains, especially in the visual memory tests. Postoperative cognitive decrease depends on the patient's age, education and mood. Postoperative cognitive decrease does not depend on the type of surgery, anesthesia and duration of anesthesia.

## Conflict of interest

None declared.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None declared.


## Ethics

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals.

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