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Original research

Intraoperative monitoring of cerebral NIRS oximetry leads to better postoperative cognitive performance: A pilot study

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HIGHLIGHTS

- We use NIRS intraoperative monitoring to prevent incidents of brain desaturations.
- NIRS monitoring leads to better postoperative cognitive performance.
- NIRS may be useful in reducing POCD in patients operated on in the prone position.

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ABSTRACT

Objectives: The aim of this study is the assessment of the regional cerebral oximetry – NIRS (near infrared spectroscopy) as an intraoperative monitoring system to protect the patient against the incidents of brain desaturations. We hypothesize that patients monitored with NIRS present a smaller range of postoperative cognitive dysfunctions (POCD) in comparison with those without NIRS monitoring during lumbar spine surgery in a prone position.
Settings: This study was performed at the Clinical Department of Neurosurgery and Oncology of the Central Nervous System, Medical University of Lodz, Poland.
Participants: The study completed 43 adult patients qualified for the surgical treatment of lumbar spondylosis. Before the procedures they were randomized into two subgroups: one monitored intraoperatively by means of NIRS cerebral oximetry (INVOS 5100), which numbered 13 patients – 30.2% (13 NIRS devices were made available to the authors) and the other without NIRS intraoperative monitoring, totaling 30 people – 69.8%. The patients who presented a history of psychiatric, neurological and cardiovascular disorders which impair cognitive processes were disqualified from the study.
Primary and secondary outcome measures: A comprehensive battery of neuropsychological tests was preoperatively performed on all patients. The subjects were then divided into two groups: with and without NIRS monitoring. Both groups were statistically homogeneous. Computerized anesthesia records were used to obtain intraoperative data: mean arterial pressure, heart rate, pulsoximetry and cerebral regional oxygenation. The depth of anesthesia monitor was not used. Besides, all the patients passed the same battery of neurocognitive tests 7 days and 1 month postoperatively. The Mann–Whitney test was performed to compare POCD and therefore assess the usefulness of NIRS as a monitoring mechanism during anesthesia in the prone position.
Results: There was a significant ($p < 0.05$) difference in the presence of cognitive deficiencies between the subgroup monitored with NIRS and the subgroup without NIRS. It included: Digit Span Test overall score and forward repetition score 7 days after operation, N- back Test results after 30 days in version 0 “back” – time, N-back Test version 1 “back” results in the number of correct answers and the number of errors.

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Conclusions: NIRS cerebral oximetry may be useful in reducing postoperative cognitive complications in patients operated on in the prone positioning.
Trial registration: RNN/556/08/KB – approval of the ethics committee at Medical University of Lodz, Poland.

1. Introduction

Postoperative cognitive dysfunction (POCD) is a subtle disorder of thought processes, which may influence isolated domains of cognition such as executive functions, verbal and visual memory, language abilities, visuospatial abstraction, attention and concentration [1–3].

Research in the area of POCD reduction and improvement of clinical anesthesia to facilitate cognitive recovery is a high priority in the contemporary anesthesia. The undetected intraoperative incidents of the prefrontal cortex desaturation contribute to the development of cognitive dysfunctions disrupting cognitive performance of patients after the surgery [4,5]. Another early postoperative side effects such as emergence agitation and emergence delirium (possibly connected with desaturation) are resource consuming and may cause serious complications [6–8].

The EEG based depth-of-anesthesia monitors facilitating titration of depth of anesthesia and thus possibly reducing the risk of a too deep anesthesia and subsequent decrease in systemic blood pressure and potentially cerebral perfusion has been shown to have a possible positive effect [9–11]. Simultaneously the monitoring of oxygen saturation in the prefrontal cortex is not yet a routine. Therefore, the hypothesis that monitoring of cerebral oxygenation could improve postoperative cognitive recovery and reduce risk of cognitive side effects is worth of empirical investigation. The aim of this study is to assess the value of the cerebral oximetry monitor (NIRS, near infrared spectroscopy) in detecting and diminishing intraoperative episodes of desaturation of the prefrontal cortex in patients operated on in the prone position due to lumbar spondylosis. It has been analyzed whether there is any correlation between the reduction of intraoperative episodes of desaturation of the prefrontal cortex detected by the NIRS cerebral oximetry and postoperative level of neurocognitive performance in patients operated on in the prone orientation.

2. Methods

2.1. Subgroups of patients

After obtaining the approval of the Bioethics Committee (RNN/556/08/KB), all 43 adult patients qualified for the surgical treatment of lumbar spondylosis in the Clinical Department of Neurosurgery and Oncology of the Central Nervous System, Medical University of Lodz, Poland in the year 2012, were included in the study. The surgical procedures were performed in the prone positioning and included laminectomy, hemilaminectomy and discectomy within the lumbar spine. Before the procedures the patients were randomized into two subgroups: one monitored intraoperatively by means of NIRS cerebral oximetry (INVOS 5100, Somanetics Corporation, USA), which numbered 13 patients (30.2%) and the other without such monitoring (30 patients - 69.8%). The total number of the monitored patients in this pilot study is a result of the temporal limitation and shortage of NIRS sensors. The total number of patients is accidental.

Fisher's exact test ($p > 0.05$) showed no differences between two subgroups in terms of the participation of women and men, age, years of education, the participation of smokers, the presence of cardiovascular diseases, the presence of the symptoms of depression measured by the Beck Depression Inventory (BDI) or duration of anesthesia.

The two groups also did not differ significantly ($p > 0.05$) in the terms of: atrial fibrillation, cardiac arrhythmias, valvular diseases and the use of pharmacological treatment for the above reasons presence of diabetes, hypertension and antihypertensive therapy, hyperlipidemia and the presence of hypolipemic therapy.

2.2. Exclusion criteria

The patients with a history of neurological and psychiatric disorders which impair cognitive processes were disqualified from the study. These include previously established dementia, stroke, schizophrenia and depression. The individuals undergoing or with a history of treatment with hypnotics, antidepressants, anxiolytics and steroids were also excluded from the study. Also those, who reported frequent alcohol consumption (above 50 g per day) and whose preoperative laboratory tests showed elevated GGT (gamma-glutamyl transpeptidase) and macrocytosis with hyperchromia were disqualified. The efficiency of cognitive processes is also affected by the coexistence of cardiovascular disease, smoking and depressed mood. Comparative analysis of the breakdown of tobacco smokers and of individuals with symptoms of depression according to Beck Depression Inventory (BDI) gave similar test results. In those cases, the Fischer test revealed no significant difference between the subgroup monitored with NIRS cerebral oximetry and the one without NIRS ($p > 0.05$).

2.3. The battery of neuropsychological tests

The prefrontal cortex, where a local measurement of NIRS takes place, is the anatomical location of working memory structures, which lie at the basis of executive functions. Its image is not uniform and includes various operational stages, such as planning, initiating and monitoring progress. Therefore, in the evaluation of postoperative cognitive deficiencies a battery of tests must be employed.

All trial patients were subject to presurgical neuropsychological examinations in the form of a battery of tests such as visual working memory N-back Test (NBT), Trail Making Test A & B, (TMT A & B), Stroop Color-Word Interference Test Part 1 and 2 (Stroop 1 & 2), Verbal Fluency Test (FAS), Digit Span Test – forward and backward repetition of numbers (DST) and the Mini Mental State Examination (MMSE) [12,13].

The preoperative test results were the basis for the assessment of postoperative cognitive dysfunctions in the entire sample of the patients tested. Re-evaluation of cognitive processes with the same tests was made at 7 and 30 days after the operation. All the participants completed all the tests (there were no missing data).

The present study compared cognitive deficiencies between the group supervised with NIRS and the one without such monitoring. Description of the test sequence is shown in Fig. 1. It is assumed that