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Research Article

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Cerebral Oxygenation Changes Observed in Patients Undergoing Spinal Neurosurgery in Prone Position Using Near Infrared Spectroscopy

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Abstract

Background: *Near infrared spectroscopy (NIRS) devices like cerebral oximeters have lately gained their actuality in different medical fields. Used intraoperative they can early detect harmful event and gives a possibility to avoid from further brain damage. The goal of the study was to determine whether prone position during spinal neurosurgery impacts cerebral oxygen saturation using NIRS.*

Material and methods: *28 patients (mean age 56±12.5y) underwent spinal neurosurgery in prone position (transpedicular fixation (TPF) = 15, micro discectomy (MDE) = 8, spinal tumor removal (spinal Tu) = 5). Cerebral oxygen saturation (rScO2) was continuously monitored using INVOS 4100 cerebral oximeter. We also assessed blood loss, postoperative complications (stroke, organ dysfunction, wound infection, days spent in ICU) and cognitive dysfunction using MoCA Montreal - Cognitive Assessment scale. All patients received standard general anaesthesia. All patients were extubated in the operating room.*

Results: *Significant changes in calculated mean rScO2 values between supine and prone position during the surgery were not observed. Mean rScO2 during the whole surgery was 73% above the right cerebral hemisphere (R), 73% above the left (L). Lying supine during induction R72%, L71%, in prone position R74%, L74%, returning back to spinal position R73%, L73%. 11 out of 28 patients showed a slight to significant decrease in rScO2 values in prone position. One patient showed a rScO2 decrease by 27% from baseline value. Average blood loss was 308ml. Average duration of operation was 110min. No incidence of stroke, organ dysfunction was observed. One patient was admitted to ICU due to blood loss. One patient showed cognitive dysfunction.*

Introduction

Spinal neurosurgery is one of the surgical fields where major medical complications can occur, like - acute myocardial infarction, stroke, pulmonary thromboembolism, pneumonia, sepsis including life threatening complications [1].

One of the factors that complicate perioperative period is prone position during spinal surgery. Prone position causes significant physiological changes in a body and there are many factors that have to be kept in mind while patient is lying prone. Those changes are increased thoracic pressure with a decreased left ventricular compliance and filling, increased intra-abdominal pressure with a direct compression on vena cava inferior-both reducing ventricular volume, stroke volume and resulting in hypotension. Increased risk of abdominal compartment syndrome resulting in decreased perfusion of intra-abdominal organs with the following multi organ failure and others [2]. Arterial hypotension and decreased blood return in systemic circulation directly impacts brain circulation and its oxygen supply. Adequate oxygenation of the brain is one of the main tasks during anaesthesia although brain being one of the most important organs stays one of the least monitored organs during the surgery [3, 4].

Adverse effects of prolonged hypoxia of the brain are already well documented. There are studies showing increased incidence of neurophysiological dysfunction, prolonged hospital length of stay, major organ morbidity and mortality in patients that demonstrate cerebral oxygen desaturation episodes during surgery [5-7].

Jobsis introduced the world with the near infrared spectroscopy use in cerebral oxygen saturation monitoring already in 1977 [8]. This principle has been implemented in cerebral oximetry devices. Cerebral oximeters provide noninvasive, continuous monitoring of cerebral oxygenation giving a possibility of early harmful event detection and early intervention to avoid further damage [4, 9]. Cerebral oximeters work based on near infrared spectroscopy principle which includes wave lengths between 700-1000nm which are capable of penetrating the skull and underlying cerebral tissues

[10]. Two electrodes have been attached to the patient's forehead and incorporate light emitter and light detector. Near infrared light coming from emitter is further absorbed in the cerebral tissue and based on the fact that oxyhemoglobin and deoxyhemoglobin absorbs the near infrared light differently we can estimate the oxygen usage in the brain. First cerebral oximeters have been used already 30 years ago but only lately have gained their popularity in different medical fields.

Materials and methods

28 patients (male 16, female 12, medium age 56±12.5 years) were scheduled for spinal neurosurgery in prone position (transpedicular fixation - 15, micro discectomy - 8, removal of spinal tumours - 5). Regional cerebral oxygen saturation (rScO2) was continuously monitored throughout the whole surgery using INVOS 4100 NIRS cerebral oximetry device. Baseline rScO2 values were determined before the induction of anaesthesia. The accepted normal rScO2 values were between 60-80%. NIBP, HR, EtCO2, SpO2 were also monitored. All patients received standard general anesthesia: induction with fentanyl 0.1-0.2mg, propofol 1-2mg/kg, cisatracurium 0.2mg/kg; maintenance with fentanyl 0.03-0.06μg/kg/min, cisatracurium 0.06-0.1mg/kg/h, and sevoflurane to MAC 0.7-1.0, FiO2 0.5. After the surgery all patients were extubated in the operating room.

We also assessed intraoperative blood loss and postoperative complications (stroke, organ dysfunction, wound infection, days spent in intensive care unit (ICU)) and cognitive dysfunction. Cognitive function was assessed using MoCA Montreal - Cognitive Assessment scale before surgery and 2 days after the surgery. MoCA scores range between 0 and 30. A score 26 or over is considered to be normal.

Statistical analysis was performed using SPSS V.23.

Results

We didn't observe any significant changes in our calculated mean rScO2 values between supine and prone position. Mean rScO2 during induction of anaesthesia was 71% above the left cerebral hemisphere, 72% above the right. When the patient was lying in prone position during surgery, mean rScO2 values were 74% above both cerebral hemispheres. Mean rScO2 at the end of surgery when the patient was lying again supine, was 73% above the left and 73% above the right cerebral hemisphere (**Figure 1**).

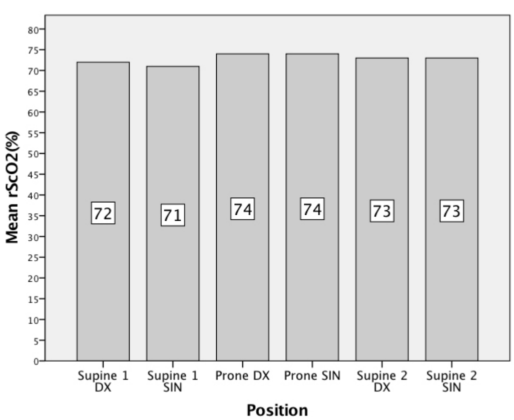

Figure 1: Mean rScO2 (%) values-supine and prone position (Supine1-supine position during induction of anaesthesia; Supine2- supine position at the end of the operation)

Medium rScO2 throughout the whole surgery was 73%± 1.4. The lowest rScO2 values were observed in spinal tumor group: TPF 73% ± 1.25, MDE 76% ± 0.69, Spinal Tu 68% ± 0.90.

Despite our calculated mean rScO2 values, 11 out of 28 patients showed a mild to moderate decrease in rScO2 during prone position with a maximum decrease of 27% in rScO2 from the patient's individual baseline (**Figure 2**).

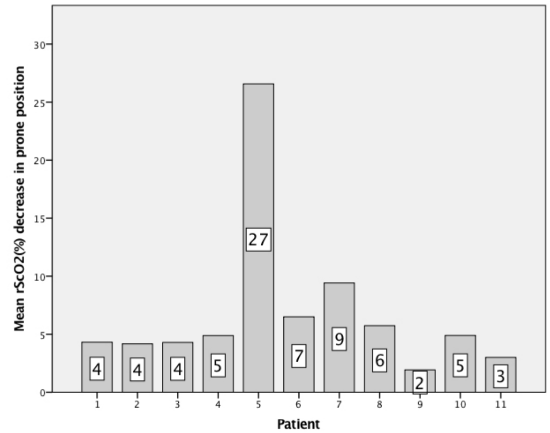

Figure 2: Mean intraoperative rScO2 (%) decrease in prone position from baseline values observed in 11 patients.

The average duration of operation was 110min (TPF=112min; MDE=125min; spinal Tu=126min).

The medium blood loss was 308 ml (TPF=400ml; MDE=175ml; spinal Tu=200ml).

The medium arterial pressure (MAP) was 87 mmHg±7.4. We observed a medium strong correlation between MAP and medium rScO2 values (r=0.31).

We didn't observe any postoperative complications like wound infections, severe organ dysfunction. One patient was admitted to ICU due to intraoperative blood loss management.

We observed a mild cognitive decline for 1-3 points in MoCA scale in 8 patients with a medium rScO2 of 69% in this patient group. One patient showed cognitive dysfunction with the MoCA 27 points before surgery and MoCA 23 points 2 days after the surgery which correlates with patients lower intraoperative rScO2 values of medium rScO2 62% compared to overall average intraoperative rScO2 73% in the whole patient group.

Discussion

Oxygen metabolism in the brain can be detected using different monitoring techniques, like jugular venous oximetry, brain tissue oxygen monitoring (PbO2) - Clark electrode or cerebral micro dialysis, but those are all invasive methods restricting their daily routine use, especially intraoperative [9]. Cerebral oximeters are non-invasive monitors which are easy to use and can provide additional intraoperative patient safety.

Although our first experience showed that there are no significant changes in mean rScO2 values in prone position during spinal neurosurgery, Deiner et al. in his study showed that a mild cerebral desaturation event was 2.30 times more likely for a patient in prone position compared to supine in elderly patient population (>68 years) [11], which is an important mark as the patient population is becoming older.

Postoperative cognitive dysfunction or decline following surgery is a raising issue [14] and can impair postoperative patient recovery [15]. In our study we observed a mild cognitive decline in 8 patients and cognitive dysfunction in 1 patient which shows a total cognitive impairment in around 1/3 of our patients. Steinmetz et al. in his study has shown that around 1/6 of patients undergoing non-cardiac surgery can present postoperative cognitive dysfunction [12]. In regard to spinal surgery, Trafidlo et al. showed a significant ($p<0.05$) difference in the presence of cognitive deficiencies between the patient groups-one that received intraoperative rScO2 monitoring and one that didn't receive it during spinal neurosurgery in prone position [13].

Evaluating intraoperative changes in rScO2 values is a complex decision making process, since values are affected by many variables, like intraoperative blood loss, patient's hemoglobin level, medications used during operation as well as the patient's comorbidities. Still cerebral oximetry remains a valuable intraoperative monitoring device.

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