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Cerebral Oximetry and Cognitive Dysfunction in Elderly Patients Undergoing Surgery for Hip Fractures: A Prospective Observational Study

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Abstract: *Aim:* This study was conducted to examine perioperative cerebral oximetry changes in elderly patients undergoing hip fracture repair and evaluate the correlation between regional oxygen saturation (rSO_2) values, postoperative cognitive dysfunction (POCD) and hospital stay.

Materials and Methods: This prospective observational study included 69 patients. Data recorded included demographic information, rSO_2 values from baseline until the second postoperative hour and Mini Mental State Examination (MMSE) scores preoperatively and on postoperative day 7. MMSE score ≤23 was considered evidence of cognitive dysfunction. Postoperative confusion or agitation, medications administered for postoperative agitation, and hospital length of stay were also recorded. Data were analyzed with Student's t-test, Pearson's correlation or multiple regression analysis as appropriate.

Results: Patient age was 74±13 years. Baseline left sided rSO_2 values were 60±10 and increased significantly after intubation. Baseline rSO_2 L<50 and <45 was observed in 11.6% and 10.1% of patients respectively. Perioperative cerebral desaturation occurred in 40% of patients. MMSE score was 26.23 ± 2.77 before surgery and 25.94 ± 2.52 on postoperative day 7 (p=0.326). MMSE scores ≤ 23 were observed preoperatively in 6 and postoperatively in 9 patients. Patients with cognitive dysfunction had lower preoperative hematocrit, hemoglobin, SpO_2 and rSO_2 values at all times, compared to patients who did not. There was no correlation between rSO_2 or POCD and hospital stay. Patients with baseline rSO_2 <55 required more medications for postoperative agitation.

Conclusion: Cognitive dysfunction occurs preoperatively and postoperatively in elderly patients with hip fractures, and is associated with low cerebral rSO_2 values.

Keywords: Anemia, anesthesia, cerebral oximetry, cognitive dysfunction, elderly, hip fracture, monitoring.

INTRODUCTION

Postoperative cognitive dysfunction (POCD) is an issue that has received significant attention in recent years. The incidence of POCD varies by patient population, but seems higher in cardiac surgery and vascular surgery patients and in the elderly [1]. Patient age, low educational level and previous cerebro-vascular accident [2] are known risk factors for developing POCD, whereas the type of anesthesia does not seem significant [3]. Proposed mechanisms leading to POCD include brain tissue hypo-perfusion, hypoxia or embolism, and the effects of anesthetic agents on the brain.

Trans-cranial cerebral tissue oximetry is a useful tool for monitoring patients undergoing cardiac or vascular surgery and for elderly patients. Normative range for cerebral regional oxygen saturation (rSO_2) is defined as values from 55 to 78 [4]. Cerebral oximetry values are influenced by age, arterial hemoglobin oxygen saturation (sPO_2), carbon dioxide partial pressure, hemoglobin concentration and cardiac index [5-7]. Low cerebral rSO_2 values and episodes of cerebral desaturation are associated with POCD and prolonged hospital stay [8].

However, more data are needed to better evaluate the role of cerebral rSO_2 monitoring in different patient populations [9]. Elderly patients with hip fractures are challenging because they have co-morbidities that could influence rSO_2 values [10, 11]. Furthermore, massive or limited fat embolism can result in reduced cerebral rSO_2 values in patients with hip fractures [12].

This study was conducted to evaluate changes of cerebral rSO_2 values and investigate whether cerebral rSO_2 changes are associated with postoperative cognitive decline in elderly patients undergoing hip fracture surgery.

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MATERIALS AND METHODOLOGY

This prospective observational study was conducted at the University Hospital of Ioannina over a twenty month period in 2008 and 2009. The study was approved by the Institution Ethics Committee and written informed consent was obtained from all patients. In total, 69 patients (27 men, 42 women) scheduled to undergo surgery for isolated sub-trochanteric or inter-trochanteric hip fractures enrolled.

Inclusion criteria were age > 60, operation (scheduled or urgent) for isolated hip fracture, American Society of Anesthesiologists (ASA) physical status 1-3 and patient consent.

Exclusion criteria were age > 90, ASA physical status > 3, renal failure requiring hemodialysis, liver cirrhosis with ongoing liver dysfunction (elevated baseline bilirubin or prolonged INR), known dementia, stroke or other central nervous system disease, history of serious psychiatric illness, alcohol or drug abuse, multiple trauma and the presence of head injury.

Demographic information (age, sex, height, and weight), co-morbidities, ASA physical status, hemoglobin, hematocrit (Hct) and type of anesthesia (general or subarachnoid) were recorded preoperatively on all patients. Cognitive function was assessed preoperatively and on the 7th postoperative day, using the MMSE test.

On arrival to the operating room a venous catheter, electrocardiography (Lead II), cuff for non-invasive blood pressure measurement, pulse oximetry and sensors for cerebral oximetry were placed. Supplemental oxygen administration (40% by Venturi mask) started after baseline rSO2 values were recorded.

The INVOS 5100C (Somanetics Inc., Troy, MI, 48083-4208 USA) monitor was used to measure cerebral rSO_2 values, with sensors placed on the patients' forehead, in accordance with manufacturer's instructions. Baseline rSO_2 value was defined as the average value over a 1-min period beginning approximately 3 min after application of the sensors, but before administration of oxygen and induction of anesthesia. Cerebral rSO_2 data were recorded every 10-seconds.

The choice of anesthesia (general of spinal) was determined by the attending anesthesiologist responsible for each case. General anesthesia was induced with intravenous fentanyl 1.5 μg/kg and propofol 1-2 mg/kg. Rocuronium 0.6 mg/kg was used for muscle relaxation. General anesthesia was maintained with sevoflurane, and depth of anesthesia was adjusted by titrating end-tidal (ET) sevoflurane concentrations between 1 and 2.5% in order to maintain adequate depth of anesthesia, as measured by BIS (BIS Module for the S/5 monitoring system by Datex, Ohmeda, Beaverton, Oregon 97006, USA, BIS Module type E-BIS-00 by GE Healthcare, Helsinki, Finland). Supplemental intravenous fentanyl boluses (2-3 μg/kg) were administered as needed to maintain cardiovascular stability. Initial mechanical ventilation settings were 40% oxygen in air, tidal volume 8 ml/kg; respiratory rate 10-12/min; subsequently, settings were adjusted in order to maintain ET CO_2 between 35 and 37 mmHg. Spinal anesthesia was induced with injection of ropivacaine 7.5 mg/kg (3 mls in total) using a 26G needle at the L2/L3 or L3/L4 interspace, with the midline approach. Mean arterial pressure (MAP) and heart rate remained within 20% of preoperative values in all patients, regardless of the type of anesthesia.

Anesthesia management was aimed at maintaining cerebral rSO_2 above 75% of baseline. Cerebral desaturation (evidence of cerebral hypoxia) was defined as rSO_2 reduction below 75% of baseline or below 50 for more than 15 seconds. When cerebral desaturation occurred, anesthesia providers followed the following treatment algorithm:

- Inspect the ventilator, anesthetic circuit and position of the head.
- Increase blood oxygenation by increasing FiO_2.
- Maintain ET $PaCO_2$ within the upper range of normal. Reduce minute ventilation, to allow ET CO_2 partial pressure to rise if ET CO_2 was < 35 mmHg.
- Restore MAP to baseline if it has dropped by more than 20% below baseline. If INVOS values remain low, then increase MAP by up to 20% above baseline, using intravenous fluids and vasoconstrictors (phenylephrine and/or etilephrine).
- Transfuse packed RBCs in cases where hematocrit is < 27%.
- If the above steps do not restore acceptable rSO_2 values, then give intravenous propofol 0.5 mg/kg bolus to reduce cerebral oxygen consumption.
- In cases of hemodynamic instability, measure cardiac output through a peripheral arterial catheter using the Vigileo system (Edwards LifeSciences, Irvine California 92614-5686, USA) or through trans-esophageal Doppler (CardioQ ODM, Model number 9051-6935, Deltex Medical LTD, PO 19 8TX, UK), and continue hemodynamic stabilization based on hemodynamic data.

Cerebral rSO_2 values were recorded 20 minutes after induction of anesthesia, at the end of surgery and 10 minutes after arrival to the recovery room. In addition, minimum and maximum rSO_2 values were also recorded.

Data collected included hemoglobin and hematocrit values on postoperative day one, hospital length of stay, occurrence of confusion or agitation and the use of medications to treat confusion or agitation. Pharmacologic treatment for confusion or agitation was directed in all cases by the same psychiatrist. In order to maintain consistency, each patient had MMSE preoperatively and one week after surgery by the same examiner. Compared to baseline, reduction of MMSE score by ≥ 2 points was considered evidence of cognitive decline [13].

As this was an observational study, we did not conduct power analysis and there was no randomization or blinding. Data were collected, de-identified and stored in a secure electronic database. All data analysis (except for chi-square) was done with the Statistical Package for the Social Sciences (SPSS) version 17 for Windows (SPSS Inc., Chicago, IL, USA). Chi-square analysis was conducted using the StatCalc component of the Epi Info statistical software package, which is freely available from the website of the Center for

Disease Control and Prevention, at http://wwwn.cdc.gov/epiinfo/. Normality of data was analyzed with the Kolmogorov Smirnov test. Continuous data were analyzed for differences between groups using the two-sided Student's T test, paired T-test or Mann-Whitney U as appropriate. Differences between proportions were analyzed with the chi-square test using Yates correction. Correlations between continuous variables were evaluated with Pearson's r, Spearman's rho, as appropriate. Depending on data distribution, results are presented as mean ± standard deviation (SD) or as median (minimum, maximum).

RESULTS

Of 75 patients who were screened, six patients could not cooperate for MMSE and were excluded. Sixty-nine patients, 27 men (39.1%) and 42 women (60.9%), ages 74±8 years completed the study. 19 of 69 patients (27.5%) were classified as ASA physical status 1, 27 (39.1%) as ASA 2 and 23 (33.3%) as ASA 3. Patient age, preoperative and postoperative hemoglobin and hematocrit, and SpO_2 values are listed in Table **1**.

Baseline cerebral rSO_2 was 60.09±10.20 on the left (baseline rSO_2 L) and 58.64±9.92 on the right side (baseline rSO_2 R). Distribution of baseline rSO_2 values was normal bilaterally. Correlation between right and left-side rSO_2 baseline values was strong and highly significant (r=0.85, $p<0.001$).

Compared to baseline, cerebral rSO_2 values increased significantly in both hemispheres 20 minutes after anesthesia induction, at the end of surgery and in the recovery room ($p<0.05$). Minimum intra-operative rSO_2 values were 50.36±9.7 (range 27–65) on the right *vs* 51.36±9.47 (range 32-64) on the left side (Table **2**).

Cerebral Desaturations

Preoperatively: Baseline rSO_2 < 50 and < 45 was observed in 11.6 % and 10.1 % of patients on the left side respectively.

Intra-operatively: rSO_2 < 50 or under 75% of baseline was observed in 38% of patients on the left and 45% of patients on the right side. Reduction of rSO_2 by more than 10 points below baseline was recorded in 34.78% of patients on the left and 30.43% of patients on the right side. Cerebral desaturation was not associated with reductions of arterial oxygen saturation. Minimum rSO_2 <50 was observed at some point in 40% and 50% of patients on the left and right hemisphere respectively.

Recovery room: rSO_2 values <50 or reduction under 75% of baseline occurred in 5.8% of patients on the left and 11.6% of patients on the right side. Similarly, rSO_2 values <45 occurred in 2.89% of patients on the left and 4.35% of patients on the right side. Differences between baseline *vs* peri-operative or recovery room rSO_2values were statistically significant ($p<0.001$).

rSO_2 Values and Type of Anesthesia

Fifty-two patients received general anesthesia and 17 patients received spinal anesthesia (Table **3**). Demographic data, baseline rSO_2 values, and preoperative and postoperative hematocrit did not differ significantly between patients receiving general *vs* spinal anesthesia.

With regards to cerebral rSO_2 values, there were no significant differences between general *vs* spinal anesthesia 20 minutes after anesthesia induction, at the end of surgery or in the recovery room. Furthermore, minimum rSO_2 values, duration of minimum rSO_2 values and duration of hospital stay did not differ between patients receiving general *vs* spinal anesthesia.

Mini Mental State Examination

Overall, MMSE score was 26.23 ± 2.77 preoperatively and 25.94 ± 2.52 one week after surgery (p=0.326). MMSE scores were similar in patients who received general anesthesia, compared to those who received spinal anesthesia.

MMSE score ≤23 was recorded preoperatively in 6 patients (8.69%) with baseline rSO_2 < 50. MMSE score ≤23 was recorded postoperatively in 3 more patients (a total of 9 patients = 13.04%). Cognitive function decline (reduction of MMSE ≥ 2 points below baseline) was observed in 9 patients (13.04%) in the first week after surgery.

Patients who developed cognitive dysfunction had significantly lower preoperative hematocrit, hemoglobin and SpO_2. and significantly lower cerebral rSO_2 values at all times, compared to patients who did not develop dysfunction. Comparisons between patients who developed cognitive dysfunction *vs* those who did not are presented in Table **4**.

Duration of hospital stay did not differ between patients who did *vs* those who did not develop postoperative cognitive dysfunction (p = 0.772).

Table 1. Age, Preoperative and Postoperative Hematocrit, Hemoglobin and SpO2 Values

	Mean ± SD	Minimum	Maximum	Median
Age (year)	74.4 ± 13.3	60	91	75
Preoperative hematocrit (%)	35.9 ± 4.8	25	47	35.9
Preoperative Hb (gm/dl)	11.8 ± 1.8	8.4	16.2	11.9
Postoperative Ht (%)	32.8 ± 3.8	26	42	32.7
Postoperative Hb (gm/dl)	10.7 ± 1.4	8.0	13.0	10.6
Preoperative SpO_2	96.0 ± 2.3	88	99	97
Postoperative SpO_2	97.0 ± 2.1	90	99	97

Table 2. rSO_2 Values at Baseline, 20 Min After Anesthesia Induction, Intraoperative Minimum and Maximum, at End of Surgery and in the Recovery Room

Time	Right Hemisphere	Left Hemisphere	p
Baseline	58.64 ± 9.91 [34-79]	60.09 ± 10.20 [38-88]	0.031
20 minutes after induction	61.99 ± 8.88*[36-78]	62.86 ± 9.00*[44-87]	NS
Intraoperative minimum	50.36 ± 9.70[27-73]	51.36 ± 9.47[32-77]	NS
Intraoperative maximum	72.25 ± 9.02[52-90]	73.39 ± 8.92[55-89]	NS
End of surgery	61.14 ± 9.51*[37-86]	62.03 ± 9.18*[35-86]	NS
In the recovery room	63.42 ± 11.18*[28-86]	64.33 ± 10.60*[34-89]	NS

Data are presented as mean ± SD (minimum, maximum).
* $p < 0.05$ compared to baseline, NS means Not Significant.

Table 3. rSO_2 Values and Anesthetic Technique

	General (n=52)	Spinal (n=17)	p
Sex (men/women)	20/32	7/10	NS
Age	73.81 ± 14.52	76.12 ± 8.38	NS
Weight	67.06 ± 9.88	71.47 ± 15.65	NS
Preoperative Ht	35.82 ± 4.8	36.18 ± 4.82	NS
Postoperative Ht	33.41 ± 3.86	31.5 ± 1.30	NS
Baseline rSO_2 L	59.73 ± 10	61.18 ± 11.00	NS
Baseline rSO_2 R	58.23 ± 9.85	59.88 ± 10.00	NS
Minimum rSO_2 L	50.83 ± 9.32	53.00 ± 10.00	NS
Minimum rSO_2 R	50.06 ± 9.79	51.29 ± 9.67	NS
Duration of min rSO_2 L	49.9 ± 42.54	51.18 ± 24.60	NS
Maximum rSO_2 R	72.96 ± 9.07	70.06 ± 8.74	NS
rSO_2 L at 20´	62.79 ± 8.56	63.06 ± 10.53	NS
rSO_2 R at 20´	61.83 ± 8.96	62.47 ± 8.86	NS
rSO_2 L in recovery	65.38 ± 10.39	61.12 ± 10.9	NS
rSO_2 R in recovery	64.48 ± 11.48	60.18 ± 9.81	NS
Hospital stay (days)	9.90 ± 4.53	8.94 ± 2.54	NS

Data are presented as mean ± SD, NS means Not Significant.

Low Baseline rSO_2 Values and Outcome

Correlation and regression analysis did not show any association between baseline cerebral rSO_2 values and outcome variables (length of hospital stay, agitation, confusion). However, further analysis using independent samples t-test showed that, compared to patients with baseline rSO_2 L ≥ 55, patients with baseline rSO_2 L < 55 had significantly lower preoperative hematocrit (33.11 ± 3.99 *vs* 37.21 ± 4.57, $p < 0.001$), and also had significantly lower intra-operative, minimum and recovery room rSO_2 values.

Similarly, parametric (t-test) and non-parametric testing (Mann-Whitney test) showed that patients with baseline rSO_2 L < 55 required significantly more medications for treatment of postoperative agitation. However, hospital stay did not differ between these two patient groups.

Table 4. Baseline, Intraoperative and Outcome Data in Patients who Did *vs* Patients who Did Not Develop Cognitive Dysfunction

	Cognitive Dysfunction		p
	Yes (n=18)	No (n=51)	
Age	76.65 ± 8.65	73.63 ± 14.44	NS
Preoperative Ht	33.32 ± 4.44	36.76 ± 4.60	0.009
Preoperative Hb	10.73 ± 1.56	12.20 ± 1.69	0.002
Postoperative Ht	33.67 ± 3.22	32.57 ± 3.51	NS
Postoperative Hb	10.26 ± 1.15	10.82 ± 1.44	NS
Preoperative SpO_2	94.82 ± 2.90	96.63 ± 1.92	0.004
Baseline L	53.71 ± 10.69	62.17 ± 9.21	0.002
Baseline R	53.06 ±12.10	60.46 ± 8.45	0.007
rSO_2 L at 20 min	55.35 ± 9.10	65.31 ± 7.60	<0.001
rSO_2 R at 20 min	55.00 ± 9.20	64.27 ± 7.54	<0.001
Min rSO_2 L	42.35 ± 6.40	54.31 ± 8.41	<0.001
Min rSO_2 R	42.00 ± 7.80	53.10 ± 8.70	<0.001
rSO_2 L end	56.76 ± 9.86	63.75 ± 8.35	0.006
rSO_2 R end	56.29 ± 8.91	62.73 ± 9.24	0.014
rSO_2 L recovery	57.53 ± 12.10	66.56 ± 9.14	0.002
rSO_2 R recovery	56.18 ± 12.63	65.79 ± 9.67	0.002
Days in hospital	9.41 ± 3.18	9.75 ± 4.43	NS
Agitation	0.12 ± 0.33	0.13 ± 0.40	NS

Comparisons using student's t test.
$P<0.05$ was considered significant for all comparisons, NS means Not Significant.

DISCUSSION

The number of elderly people requiring surgery has increased significantly due to increasing life expectancy [8], and aging is accompanied by reduced physiological reserve and numerous co-morbidities. Compared to subjects younger than 65 years, peri-operative complications and postoperative cognitive decline occur more frequently in elderly patients [14]. In our study mean patient age was 74 years.

The main findings of our study were the wide range of observed rSO_2 values (baseline rSO_2 L=60±10, range 34-88, minimum intra-operative rSO_2 50.36±9.7, range 27-73, maximum intra-operative values 72.25±9.02, range 52-90) and the high percentage of patients with peri-operative rSO_2 < 55. Cognitive dysfunction was evident preoperatively in 6 (8.69%) of patients, compared to 9 (13%) patients postoperatively, despite a protocol to optimize cerebral oxygen supply/demand. MMSE values one week after surgery did not differ significantly compared to baseline (p = 0.326). The absence of a significant difference between pre-operative and postoperative MMSE values could be explained by the protocol to promptly treat intra-operative cerebral desaturation. Preoperative cerebral desaturation was documented in several patients, and may have contributed to the preoperative cognitive dysfunction observed in our study. Similarly, the observed improvement of cerebral rSO_2 after induction of anesthesia, and the protocol used to preserve intra-operative cerebral perfusion and oxygenation may have protected the CNS from further insult.

Madsen *et al*. established that the normal range for rSO_2 values in 39 resting subjects without cardio-respiratory disease is 55-78 [4], whereas Kim *et al*. reported that mean baseline rSO_2 value was 71 ± 6 in healthy volunteers aged 20-36 years [6]. Similarly, Casati *et al*. reported baseline values 63 ± 8 in healthy elderly (72 ± 5 years) general surgery patients [8], while Edmonds *et al*. reported baseline values 67 ± 10 in 1000 patients (ages 20-90 years) undergoing cardiac surgery [15].

Our findings (low baseline rSO2 values with wide variability of baseline rSO_2 values), can be explained by patient age, low preoperative hematocrit values and perhaps inadequate preoperative fluid resuscitation. In addition, cerebral fat embolism, although a rare event, may contribute to low preoperative rSO2 values.

Cerebral rSO_2 values increased significantly after blood transfusion in our study. This finding is in agreement with the study by Kishi *et al*., which showed negative correlation between cerebral rSO_2 and age, and positive correlation with hemoglobin concentration [5]. Similarly Liem *et al*. reported positive correlation between rSO_2 and hematocrit in newborn infants [16], whereas Yoshitani *et al*. documented positive correlation of rSO_2 with hemoglobin and MAP [17]. Green also reported positive correlation between rSO_2 and hemoglobin, and negative correlation with blood loss [10]. In our study, patients with rSO_2 < 55 had significantly lower hematocrit compared with those having rSO_2 >55.

A significant correlation between reductions of rSO_2 and SpO_2 in healthy adults was mentioned by Germon *et al.* [18]. However, in agreement with results reported by Pedersen *et al.* [19], our study did not show any association between intraoperative cerebral desaturation measured by INVOS and arterial desaturation measured by pulse oximetry.

Depression of the cardiovascular system by general anesthesia can cause inadequate brain perfusion and perhaps result in postoperative neuropsychological dysfunction in elderly patients [20]. Similarly, a study on 60 geriatric (>60 years old) patients undergoing repair of proximal femur fracture, showed that, although cerebral desaturation was more common in patients having spinal anesthesia, the number of patients with at least one rSO_2 dip below baseline did not differ between groups [21]. However, the use of general *vs* spinal anesthesia did not affect cerebral oxygen saturation (rSO_2) or postoperative outcome in our study.

Cognitive function was assessed in our study using the MMSE test, and we considered values ≤ 23 as evidence of cognitive dysfunction. Advantages of the MMSE test include high validity and reliability, ease of use, brevity and suitability for bedside use [22]. In addition, MMSE is very appropriate for repeated cognitive assessments over time. Because other, more sensitive and specific tests evaluating different components of cognitive function have been proposed [3, 8, 23], use of the MMSE could be grounds for criticism. However, we believe the use of MMSE is justified, because of simplicity, and also because reduction of MMSE by 2 or more points below baseline in repeat testing is strong evidence of cognitive decline [13].

Cognitive dysfunction was observed preoperatively and persisted postoperatively in 6 patients with baseline rSO_2 < 50. Among patients with normal baseline rSO_2, three patients developed intraoperative desaturation, had postoperative MMSE ≤23, experienced postoperative agitation and were treated successfully with medications.

Overall, we did not observe any correlation between low baseline rSO_2 values or intraoperative desaturations and outcome (postoperative agitation or confusion, duration of hospital stay). Our results are in agreement with a study by Casati *et al*, which showed prolonged hospital stay in patients who developed intraoperative cerebral desaturations that went untreated [8]. Last, our study showed that patients with baseline rSO_2 < 55 required significantly more medications for agitation, but length of hospital stay did not differ between patients who did *vs* those who did not need treatment for agitation.

CONCLUSION

Our findings show that low preoperative baseline cerebral rSO_2 values are common in elderly patients with hip fractures, correlate with lower preoperative hematocrit, hemoglobin and arterial SpO_2 values and are associated with peri-operative cognitive dysfunction. Published data suggest that a multi-factorial perioperative treatment program including preoperative oxygen supplementation, intravenous fluid resuscitation and arterial oxygen saturation monitoring may reduce the incidence of delirium in elderly hip fracture patients [24], but the value of cerebral oximetry monitoring has not been established and deserves further study. We suggest that cerebral oximetry is a useful tool for monitoring elderly patients undergoing surgery for hip fractures, and could be a meaningful end-point for protocols designed to protect the central nervous system in the perioperative period. Large prospective clinical studies are needed to evaluate the benefits, if any, of monitoring cerebral oximetry in elderly patients undergoing orthopedic surgery, and validate whether this technology can contribute to improved preoperative patient preparation, fewer episodes of cerebral desaturation, less cognitive dysfunction and perhaps improvement in other outcome variables.

ETHICAL APPROVAL AND INFORMED CONSENT

This study was approved by the Institution Ethics Committee. Written informed consent was obtained from all patients who participated in the study.

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Declared none.

CONFLICT OF INTEREST

This work was supported solely by Department funds. All authors state that they do not have any conflicts of interest to report.

ABBREVIATIONS

ASA	=	American Society of Anesthesiologists
ET	=	End Tidal
Hb	=	Hemoglobin
Hct	=	Hematocrit
MAP	=	Mean Arterial Pressure
MMSE	=	Mini Mental State Examination
POCD	=	Postoperative cognitive dysfunction
rSO_2	=	regional oxygen saturation
SpO_2	=	Pulse Oximetry

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