Baseline cerebral oximetry values in elderly patients with hip fractures: A prospective observational study

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SUMMARY

Aim: This study was conducted to evaluate baseline cerebral tissue regional oxygen saturation (rSO_2) values and identify risk factors related to severe rSO_2 reductions in elderly patients with hip fractures.
Patients and methods: This was a prospective observational single-centre study on patients undergoing scheduled or urgent operation for isolated hip fracture. The study was approved by the Institution Ethics Committee, and all patients signed informed consent before entering the study. Data were collected on factors potentially related to baseline cerebral rSO_2. Data were analysed with Student's *t*-test, Pearson's correlation or multiple regression analysis as appropriate.
Results: Sixty-nine patients, aged (mean ± standard deviation (SD)) 74 ± 13 years participated. Left baseline rSO_2 was 60.09 ± 10.20 and right baseline rSO_2 was 58.64 ± 9.92. Baseline $rSO_2 < 45$ was observed in 10.1% of patients on the left and 8.7% on the right side. Correlation between left- and right-side baseline cerebral rSO_2 was highly significant ($r = 0.852$, $p < 0.001$). Baseline cerebral rSO_2 had a positive, highly significant correlation with preoperative haematocrit ($r = 0.50$, $p < 0.001$) and arterial haemoglobin oxygen saturation (SpO_2) ($r = 0.587$, $p < 0.001$), but correlation was negative with the American Society of Anesthesiologists (ASA) physical status ($r = -0.42$, $p < 0.001$) and age ($r = -0.39$, $p = 0.001$). Linear regression showed that preoperative haematocrit accounts for 23% ($R^2 = 0.23$) of baseline rSO_2 variability, whereas preoperative haematocrit and SpO_2 combined account for 43.7% of rSO_2 variability ($R^2 = 0.437$). Combined preoperative haematocrit + SpO_2 + age accounted for 51.3% ($R^2 = 0.513$) of observed rSO_2 variability.
Conclusion: Low baseline cerebral rSO_2 values are common in elderly hip fracture patients, despite normal haemodynamic and arterial saturation values. Preoperative haematocrit, SpO_2 and age explain a significant portion of cerebral rSO_2 variability. More studies are needed to validate our findings and assess the potential benefit of interventions aimed at improving cerebral rSO_2 in elderly hip fracture patients.

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Introduction

Cerebral tissue regional oxygen saturation (rSO_2) through near-infrared spectroscopy (NIRS) is a new method for non-invasive monitoring of cerebral tissue oxygenation. NIRS measures brain tissue rSO_2, which reflects the balance between brain tissue oxygen supply and demand.[1] Cerebral rSO_2 is influenced by age,[2] carbon dioxide partial pressure, arterial haemoglobin oxygen saturation,[3] cerebral blood flow and changes in cerebral metabolic rate,[4] cardiac index,[5] haemoglobin concentration[6] and blood volume.[7] Although there is no established normal range for rSO_2 values, published data suggest that normal cerebral rSO_2 is between 55% and 78%.[8–10]

Patients undergoing surgery for hip fractures can be challenging: they are usually old and often present with hypovolaemia, anaemia, pain, hyperventilation and numerous co-morbidities. Although massive life-threatening fat embolism is a rare event, embolism of lesser severity is probably common and may contribute to morbidity.[11] The aim of the present study was to establish baseline cerebral rSO_2 values and identify factors that could predict cerebral tissue hypoxia in elderly patients with hip fractures.

Patients and methods

Study design

This prospective, observational study was conducted at our tertiary care University Hospital between February 2008 and

November 2009. The study was approved by the institution ethics committee, and all patients provided written informed consent before entering the study. In total, 69 patients (27 men and 42 women) scheduled to undergo surgery for sub-trochanteric or inter-trochanteric hip fractures enrolled.

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

Exclusion criteria were refusal to participate, age > 90, ASA physical status 4 or 5, renal failure requiring haemodialysis, liver cirrhosis with liver dysfunction (elevated baseline bilirubin or prolonged INR), known dementia or serious psychiatric disease, history of alcohol or drug abuse, multiple trauma, presence of head injury or central nervous system (CNS) dysfunction and history of stroke.

Data collection

Data recorded included demographic information (age, sex, height and weight), co-morbidities, ASA physical status classification and preoperative haemoglobin and haematocrit. Baseline cerebral oximetry values were recorded on arrival to the operating room, using the INVOS (In Vivo Optical Spectroscopy) 5100C monitoring device (Somanetics, Troy, MI, USA), with sensors placed bilaterally on the patient forehead in accordance with manufacturer instructions. Baseline rSO_2 values were recorded 3 min after the sensors were applied. Supplemental oxygen administration (40% by Venturi mask) started after recording of baseline rSO_2 was completed.

Statistical analysis

As this is an observational study, there was no power analysis for sample size estimation, no randomisation and no blinding. Data were collected and stored, without any personally identifiable information, in a secure electronic database. All data analysis was done using the Statistical Package for the Social Sciences (SPSS) version 17 for Windows (SPSS Inc., Chicago, IL, USA) statistical software package. Data normality was assessed with the Kolmogorov Smirnov test. Depending on data distribution, continuous data were analysed with the Student's t-test or the Mann–Whitney U-test, as appropriate. Correlations between continuous variables were assessed with Pearson's r. $P < 0.05$ was considered significant for all comparisons. Linear regression was used to identify variables associated with baseline rSO_2 and analyse the contribution of these variables to the observed baseline rSO_2 variability. Scatterplots demonstrating correlations between different variables were constructed using the 'Statistica' version 7 statistical software package (StatSoft Inc., Tulsa, OK, USA). Depending on data distribution, results are reported as mean $\pm$ standard deviation (SD) or as median (minimum and maximum).

Results

Sixty-nine patients, 27 men (39.1%) and 42 women (60.9%), aged 74 ± 13 years enrolled. A total of 19 of the 69 patients (27.5%) was classified as ASA physical status I, 27 (39.1%) as ASA II and 23 (33.3%) as ASA III. Demographic and clinical data, including preoperative haematocrit and haemoglobin, and baseline rSO_2 values from the left (baseline rSO_2 L) and the right (baseline rSO_2 R) cerebral hemisphere are summarised in Table 1.

Baseline rSO_2 values had normal distribution bilaterally. Baseline rSO_2 was higher on the left side (60.09 ± 10.20 vs. 58.64 ± 9.92, $p = 0.031$ by paired t-test), but this difference, although statistically significant, is very small. Correlation between left and right baseline rSO_2 values was positive and highly significant (Pearson's $r = 0.852$, $p < 0.001$, Fig. 1).

Table 1
Demographic data, clinical data and baseline rSO_2 values in patients with isolated hip fractures.

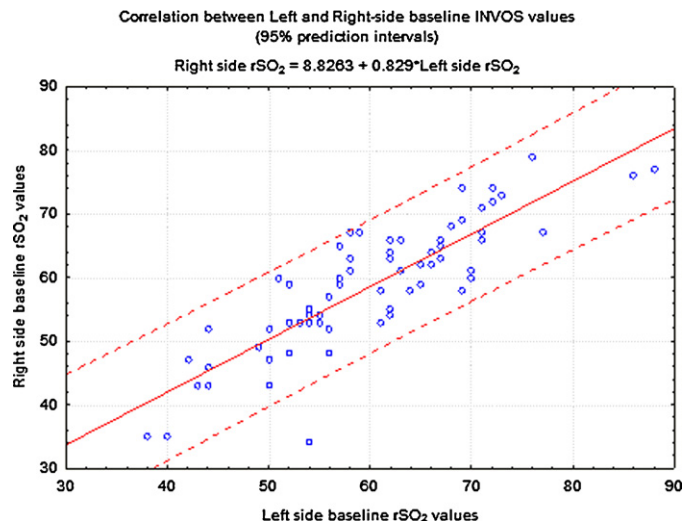|	Mean $\pm$ SD	Minimum	Maximum	Median
Age (year)	74.38 ± 13.26	60	91	75
Body weight (kg)	68.14 ± 11.59	45	110	68
Height (cm)	161.13 ± 8.28	145	186	160
BMI	26.22 ± 3.91	18.73	40.06	26.5
Preoperative Ht (%)	35.91 ± 4.77	25	46.9	35.85
Preoperative Hb (g/dl)	11.84 ± 1.77	8.4	16.2	11.95
Baseline rSO_2 L (%)	60.09 ± 10.20	38	88	58.50
Baseline rSO_2 R (%)	58.64 ± 9.92	34	79	59

Fig. 1. Correlation between left and right side baseline rSO_2 values.

Baseline $rSO_2 < 55$ was documented in at least one cerebral hemisphere in 40.6% (28 of 69) patients, baseline $rSO_2 < 50$ in 18.8% (13 of 69) patients, baseline $rSO_2 < 45$ in 13.0% (9 of 69) patients and baseline $rSO_2 < 40$ in 4.3% (3 of 69) patients (Table 2).

Baseline values and sex

Men were younger (70.63 ± 16.72 years vs. 76.79 ± 9.94 years, but this difference did not quite reach statistical significance, $p < 0.059$), heavier (72.52 ± 10.49 kg vs. 65.33 ± 11.51 kg, $p < 0.011$) and taller (168 ± 4.59 cm vs. 156.71 ± 7.03 cm, $p < 0.001$) than women. Preoperative haemoglobin (11.87 ± 2.14 vs. 11.81 ± 1.50), haematocrit (35.75 ± 5.88 vs. 36.01 ± 3.97), ASA physical status and left- and right-side baseline rSO_2 values did not differ significantly between men and women. Demographic and clinical data in men vs. women are summarised in Table 3.

Predictors of baseline rSO_2

Body weight, height and body mass index (BMI) did not have any correlation with baseline rSO_2 values. However, preoperative haematocrit had a strong, highly significant positive correlation

Table 2
Percentage of baseline rSO_2 values <55, 50, 45 and 40.

Baseline rSO_2 values	Right side (%)	Left side (%)	Lowest value (either side)
<55	34.8	31.9	40.6
<50	17.4	11.6	18.8
<45	8.7	10.1	13
<40	4.3	1.4	4.3