

Continuous Noninvasive Hemoglobin Measurement Is Useful in Patients Undergoing Double-Jaw Surgery

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Purpose: Continuous measurement of hemoglobin by pulse CO-oximetry (SpHb; Masimo Radical 7 device, Masimo Corp, Irvine, CA) may be helpful during double-jaw surgery when massive hemorrhage is anticipated. Given the possible influence of low blood pressure on the detection of hemoglobin levels, the agreement of the SpHb was evaluated in patients undergoing orthognathic surgery when using hypotensive anesthesia.

Materials and Methods: Patients who underwent elective Le Fort I osteotomy and bilateral sagittal split ramus osteotomy (BSSO) were enrolled in this observational prospective cohort study. SpHb was compared with time-matched arterial total hemoglobin (tHb) before incision, at Le Fort I osteotomy, at BSSO, and at skin closure. The correlation between simultaneous SpHb and tHb measurement pairs was evaluated. Agreement was assessed by a comparison of SpHb with tHb using the intraclass correlation coefficient (ICC) and the Bland-Altman plot.

Results: The average age of 51 patients was 23 ± 5 years and 32 patients were male. The correlations of SpHb and tHb measurements were 0.72, 0.85, 0.89, and 0.78 before incision, at Le Fort I osteotomy, at BSSO, and at closure, respectively. Bland-Altman analysis for SpHb and tHb showed respective bias values of 0.12, 0.07, -0.09, and -0.90 g/dL. ICC values between SpHb and tHb were 0.82, 0.90, 0.91, and 0.87, respectively.

Conclusions: Continuous monitoring of hemoglobin may help to determine the appropriate time to perform an invasive measurement of hemoglobin in patients who undergo double-jaw surgery.

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J Oral Maxillofac Surg 72:1813-1819, 2014

Measurement of hemoglobin concentration is one of the most important laboratory tests in patients who undergo double-jaw surgery. Clinicians decide to perform erythrocyte concentrate transfusion based on laboratory hemoglobin measurements and other

clinical parameters determined from patients. The gold standard for the measurement of hemoglobin concentration is an automated analyzer in a clinical laboratory.¹ However, the limitations of laboratory-based measurement of hemoglobin are the

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Support was provided solely from institutional or departmental sources.

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Received January 22 2014

Accepted March 8 2014

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0278-2391/14/00324-3\$36.00/0

<http://dx.doi.org/10.1016/j.joms.2014.03.011>

requirement for a higher cost to the facility, invasive blood sampling, the dissipation of blood associated with the need for repeated measurements, and the time requirements associated with the need to obtain a result.² Continuous monitoring of hemoglobin levels may be helpful when surgery is anticipated to be associated with massive hemorrhage.

The Masimo Radical 7 device (Masimo Corp, Irvine, CA), which uses a multi-wavelength pulse CO-oximeter (SpHb), is a noninvasive point-of-care device that enables immediate and continuous hemoglobin measurement. The capacities for continuous monitoring and noninvasive measurement of hemoglobin concentration are the primary advantages of using a SpHb. Previous studies have shown that noninvasive hemoglobin measurement with a SpHb correlates well with laboratory measurements.²⁻⁶ However, performance has been poor in certain situations, particularly in patients in cardiovascular intensive care units after cardiac surgery,⁷ obstetric patients under neuraxial anesthesia,⁸ and patients with greater-than-normal blood loss or lower-than-normal arterial hemoglobin values.⁹

Given that orthognathic surgery is performed in a highly vascularized region, the associated bleeding is often not easily controlled. Hypotensive anesthesia is frequently used as an effective technique to decrease blood loss, improve the quality of the surgical field, and decrease the duration of surgery.^{10,11} Healthy young patients can tolerate a mean arterial pressure (MAP) as low as 50 to 60 mmHg without complications.¹² However, data on the reliability of a SpHb during controlled hypotensive anesthesia are rather limited. The authors hypothesized that if the agreement of hemoglobin values between laboratory-based measurement and SpHb were clinically acceptable, then SpHb would be a good alternative to an invasive method for hemoglobin monitoring during controlled hypotensive anesthesia. The specific aim of this study was to evaluate whether noninvasively measured SpHb was comparable to invasive arterial total hemoglobin (tHb) during normotensive and hypotensive periods in patients undergoing orthognathic surgery.

Materials and Methods

STUDY DESIGN

This observational prospective cohort study was conducted at the Seoul National University Dental Hospital from October 2012 to March 2013. After approval from the institutional review board of Seoul National University Dental Hospital (CDE12003), written informed consent was obtained from every patient before participation. Patients (age range, 17 to 40 years) who underwent elective Le Fort I osteotomy and bilateral sagittal split ramus osteotomy (BSSO)

were enrolled in this study. Patients who were diagnosed with cardiopulmonary diseases, hematologic diseases, hyperbilirubinemia, uncontrolled glaucoma, cerebral vascular diseases, and peripheral vascular diseases were excluded.

VARIABLES

The primary predictor variables were tHb and time. The primary outcome variable was the SpHb. The secondary variable was MAP, which can affect the measurement of the SpHb.

ANESTHESIA AND MONITORING

Patients received no premedication before anesthesia. Induction was performed with target-controlled infusions of remifentanyl and propofol (Orchestra Base Primea, Fresenius Vial, France). The induction target of remifentanyl (4 ng/mL) was followed by a maintenance target of 3 to 10 ng/mL at the effect site. The concentration of propofol was 3 to 4 μ g/mL during the operation, and these infusions were titrated to maintain bispectral index scores (BIS Vista, Aspect Medical Systems, Inc, Norwood, MA) in the range of 40 to 60. Vecuronium (0.1 mg/kg) was injected to facilitate tracheal intubation, and additional vecuronium administration was guided by neuromuscular monitoring during the procedure. After nasotracheal intubation, patients were ventilated using volume-controlled mechanical ventilation to maintain an end-tidal CO₂ level of 35 \pm 5 mmHg with a mixture of O₂ and air (inspired oxygen fraction, 0.5). Patient temperatures were maintained at 36°C to 37°C throughout the study period. A 20-gauge catheter was placed in the dorsalis pedis artery for continuous monitoring of arterial blood pressure and blood gas analysis as part of the authors' routine anesthetic care.

DATA COLLECTION

tHb was measured using a Stat Profile pHox Plus instrument (Nova Biomedical, Waltham, MA) that was located in a room next to the operating theater. The blood gas analyzer was linked to a central laboratory and calibrated up to 3 quality control levels 3 times per day (total, 9 analyses per day) with the Auto-Cartridge QC provided by the supplier. SpHb levels were measured continuously using a Masimo Radical 7 device (software version 7.8.0.1) and a spectrophotometric adhesive sensor (version R2-25, Rev E, Masimo Corp.). Before the induction of anesthesia, the sensor was attached to the index finger of the hand, which did not have a venous cannula, and was covered with an impermeable black shield to prevent any other optical interference.

Before incision, blood pressure levels were maintained in a preinduction range by titrating the infusion

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