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# Cerebral desaturation events in the intensive care unit following cardiac surgery ☆

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**Abstract**

**Purpose:** Patients may be at high risk for hemodynamic instability in the early postoperative period, with subsequent poor cerebral perfusion and the development of postoperative cerebral oxygen desaturation events (CDEs). Intraoperative CDEs have been associated with postoperative adverse events. However, none of these studies examined the incidence of early postoperative cerebral desaturations. This study was designed to identify the incidence of CDEs (defined as a decrease in $SctO_2$ to less than 60% for at least 60 seconds) in the immediate postoperative period following cardiac surgery.

**Methods:** Fifty-three moderate to high-risk patients undergoing elective cardiac surgery were enrolled in this observational study. Cerebral oximeter monitors were placed on all patients prior to induction of anesthesia and remained in place for 6 hours or until the patients were extubated postoperatively, whichever occurred first. Data were recorded from the cerebral oximeter, physiologic monitor and ventilator during the study period. Data were analyzed to identify the incidence of early postoperative CDEs, as well as association with subsequent clinical events.

**Results:** The incidence of early postoperative CDEs was 53%. Sixty-four percent of these CDEs lasted for more than 1 hour. Patients with postoperative CDEs were more likely to have had intraoperative CDEs ($P < 0.0001$). Five out of 28 patients who experienced CDEs in the intensive care unit died while none of the patients without postoperative CDEs died ($P = .053$).

**Conclusion:** A high incidence of CDEs (53%) was found in the early post-cardiac surgery period. Larger studies are needed to determine whether postoperative CDEs are correlated with various physiologic events or are associated with adverse patient outcomes.

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## 1. Introduction

Pulse oximetry uses near-infrared spectroscopy (NIRS) to determine systemic oxygenation in intensive care units (ICUs) worldwide. Similarly, transcranial cerebral oximetry uses NIRS to reflect cerebral oxygen saturation noninvasively [1]. The use of NIRS to measure cerebral tissue oxygenation noninvasively was developed by Jobsis nearly

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four decades ago [1]. It is based on transmission, absorption, and reflectance of near infrared light in the 700- to 1000-nm range, with deoxygenated and oxygenated hemoglobin absorbing light in different ranges [2]. Two adhesive sensors are typically placed on the forehead and contain both the light source and receiver [2]. Cerebral tissue oxygen saturation ($SctO_2$) is thought to reflect a ratio of arterial and venous blood in the frontal cortex [1]. Numerous clinical trials (especially in cardiac surgery) have validated this noninvasive technology as a reliable way to detect cerebral ischemia/hypoxia [1].

The recent advances in NIRS technology (continuous wave, time and frequency domain, spatially resolved methods, and multiple wavelengths) have improved the accuracy of cerebral NIRS [2]. New generation cerebral oximeters have been developed that use 4 precise wavelengths of light to acquire information needed to calculate the $SctO_2$ [2]. This cerebral oximeter has been used in cardiothoracic and shoulder surgery trials (FORE-SIGHT cerebral oximeter system-CAS Medical System, Inc, Branford, CT) [3,4]. This device provides a value (between 65% and 75% in a normal population) that reflects an approximate ratio of 30% arterial to 70% venous blood in the frontal cortex [2]. The development of these new cerebral oximeters may allow determination of cerebral oxygen saturation thresholds to aid clinicians in deciding when to apply therapies that may improve patient outcome.

Overall mortality following coronary artery bypass grafting (CABG) and valvular heart surgery using cardiopulmonary bypass has declined. However, morbidity, especially significant cognitive and renal dysfunction, continues to be a major concern. Some studies have reported that neurocognitive dysfunction occurs in up to 60-80% of postoperative patients [2]. Cerebral oximetry has been used during heart surgery in an attempt to detect and direct treatment for cerebral ischemia in real time. The use of cerebral oximetry to detect and treat cerebral ischemia during cardiac surgery may reduce end organ dysfunction and hospital length of stay [2,5]. Slater et al demonstrated that intraoperative cerebral oxygen desaturation was associated with cognitive decline and an increase in hospital length of stay after CABG [6]. Two recent studies have suggested a low baseline cerebral oxygen saturation may correlate with increased perioperative morbidity and mortality, presumably because of a reduced safety margin in these patients [7,8].

Taken as a whole, prior studies using cerebral NIRS have suggested that preoperative and intraoperative cerebral desaturations are associated with sub-optimal postoperative outcomes [5-12]. These trials were focused on endpoints that include either in-hospital or 30-day morbidity and mortality. None of the prior trials have determined the incidence and extent of cerebral desaturations in the early postoperative period. Previous studies have suggested that a drop in $SctO_2$ to less than 60% is associated with adverse postoperative events [3,12]. The present study was designed to examine the incidence and extent of CDEs (defined in this study by a drop in $SctO_2$ to less than 60% in at least one of the applied cerebral oximeter sensors for at least 60 seconds) in the early ICU postoperative period after cardiac surgery.

## 2. Methods

This prospective observational study was approved by the institutional review board of North Shore University Health System (Evanston, IL). Written informed consent was obtained from all subjects. Fifty-three moderate- to high-operative-risk patients (as determined by the EuroSCORE evaluation tool) [13] who were scheduled for elective cardiac surgery using cardiopulmonary bypass (CPB) were enrolled. These procedures consisted of either CABG, one-valve, multi-valve, combined CABG/valve, or ascending aortic aneurysm repairs. Patients younger than 18 years and patients presenting for emergency surgery or who were scheduled for off-CPB surgery were excluded.

All study patients had $SctO_2$ measured continuously during surgery using the FORE-SIGHT cerebral oximeter system. The forehead was cleansed with alcohol and two cerebral oximeter sensors were applied. The sensors were placed bilaterally on the frontotemporal areas of each patient's forehead (located at the medial margin at the midline of the forehead and the lower margin, approximately 1 cm above the eyebrows). A CDE was defined in this study by a drop in $SctO_2$ to less than 60% in at least one of the applied cerebral oximeter sensors for at least 60 seconds. A processed electroencephalogram monitor (BIS monitor-Aspect Medical Systems; Covidien, Mansfield, MA) was also applied. Both monitor probes were placed and secured on the forehead in the preoperative holding area and covered with a towel to prevent light interference.

### 2.1. Anesthetic and surgical management

Standard American Society of Anesthesiologists monitoring was used in every patient. Monitoring also included invasive radial arterial pressure, pulmonary artery pressure (via a pulmonary artery catheter), transesophageal echocardiography and the cerebral oximeter. Anesthesia was induced using etomidate, 0.2 to 0.4 mg/kg, and midazolam, 1 to 5 mg. Rocuronium, 0.6 to 1 mg/kg, was used for intubation. Fentanyl, 2 to 4 $\mu$g/kg, was used for induction and intubation.

Anesthesia was maintained with isoflurane (0.4%-3.0%), which was adjusted to maintain the bispectral index between 40 and 60 and a target systemic blood pressure within 20% of baseline measurements throughout surgery. Achievement of this target systemic blood pressure was left up to the discretion of the cardiac surgeon and anesthesiologist. This target blood pressure was usually maintained by administering either crystalloid boluses (250-500 mL) or vasopressors (ie, phenylephrine or ephedrine). Hypertension was typically