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Sedation / Delirium

Cerebral oximetry as a biomarker of postoperative delirium in cardiac surgery patients

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ABSTRACT

Purpose: A promising monitoring strategy for delirium is the use of cerebral oximetry, but its validity during delirium is unknown. We assessed the relationship between oximetry and delirium. We hypothesized that as cerebral oximetry values increased, delirium would resorb.
Materials and methods: An observational study was conducted with 30 consecutive adults with delirium after cardiac surgery. Oximetry, delirium assessments, and clinical data were collected for 3 consecutive days after delirium onset. Oximetry was obtained using near-infrared spectroscopy. Delirium was assessed using diagnosis, occurrence (Confusion Assessment Method-ICU), and severity scales (Delirium Index).
Results: All patients presented delirium at entry. The mean oximetry value decreased from 66.4 ± 6.7 (mean ± SD) to 50.8 ± 6.8 on the first day after delirium onset and increased in patients whose delirium resorbed over the 3 days. The relationship between oximetry, delirium diagnosis, and severity was analyzed with a marginal model and linear mixed models. Cerebral oximetry was related to delirium diagnosis ($P \leq .0001$) and severity ($P \leq .0001$).
Conclusion: This study highlighted the links between increased cerebral oximetry values and delirium resorption. Oximetry values may be useful in monitoring delirium progression, thus assisting in the management of this complicated condition.

1. Introduction

1.1. Background

Delirium after cardiac surgery is not always avoidable, and its length and severity are associated to mortality and long-term cognitive impairment [1]. The American Psychiatric Association recommends that delirium assessment in clinical practice is best achieved when medical diagnosis is supplemented with observational assessment tools [2]. The criterion standard in practice is the Confusion Assessment Method (CAM), which has been validated among intensive care patients with the CAM-intensive care unit (CAM-ICU) [3]. Other tools have been validated as well; the Intensive Care Delirium Screening Checklist (ICDSC) provides information on the occurrence of delirium, whereas the Delirium Index (DI) informs on severity [4,5]. The use of these tools leads to enhanced delirium assessment when compared to clinical judgment alone [6]. However, delirium monitoring in current practice remains suboptimal.

A promising strategy is the use of biomarkers, which can support delirium monitoring without relying solely on observing manifestations. Brain oxygen saturation (cerebral oximetry), reflecting the balance between oxygen delivery and consumption, is promising. This measure also reflects cerebral blood flow, a possible contributing factor of delirium [7]. Therefore, cerebral oximetry could be used to highlight an internal process occurring during delirium. Near-infrared spectroscopy (NIRS) is a noninvasive device that measures oximetry. Previous studies have reported an association between enhanced preoperative and intraoperative cerebral oximetry and the lower risk of postoperative delirium. However, regular measurement of cerebral oximetry during delirium has not been reported. Hence, it is still unclear whether this tool is valid.

In the present study, we assessed the concurrent validity of oximetry in monitoring delirium reflected by the relationship between oximetry

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values and the occurrence and severity level of delirium as measured by validated tools. Oximetry values were measured at the cerebral and peripheral area using NIRS technology. Because we wanted to control for decrease in cerebral oximetry due to hypoperfusion reasons, we also measured peripheral oximetry values. Occurrence of delirium was measured using the medical diagnosis and the CAM-ICU, and severity of delirium was measured using the DI. We hypothesized that higher cerebral oximetry values would decrease the odd of delirium occurrence, whereas peripheral oximetry values would not. In addition, we hypothesized that higher cerebral oximetry values would be related to lower severity level of delirium, whereas peripheral oximetry values would not.

2. Materials and methods

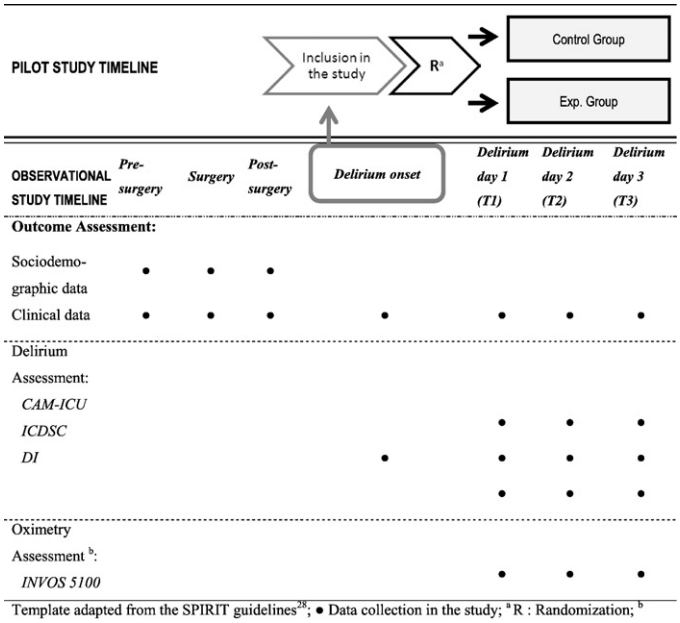
2.1. Definition of delirium

In our study, delirium is defined by a score of 4 or more on the ICDSC, matched with a medical diagnosis in the medical chart [4]. The ICDSC is described in the "Variables and data measurement" section.

2.2. Study design and setting

The present observational study is embedded in a pilot randomized controlled trial (RCT) in which the primary aim was to examine the acceptability and feasibility of a nursing intervention of delirium management [8] (Controlled Trials no. ISRCTN95736036). The study's secondary objective, which is presented in the present paper, was to assess the concurrent validity of cerebral oximetry as an indicator of delirium by examining its relationships with occurrence and severity level of delirium. The study was conducted in an ICU and surgery ward from a Canadian tertiary cardiology university hospital. Approval was obtained from the research center's ethics and scientific committee. The design and data collection sequence is presented in Table 1.

Table 1
Observational study design within the main pilot RCT



Template adapted from the SPIRIT guidelines[28]; ● Data collection in the study; [a] R : Randomization; [b] Oximetry assessment is performed using the INVOS 5100 Near Infrared Spectroscopy device (COVIDIEN, Somanetics Corporation).

Template was adapted from the SPIRIT guidelines [28]; ● indicates data collection in the study; R, randomization.
[a]Oximetry assessment is performed using the INVOS 5100 Near Infrared Spectroscopy device (COVIDIEN).

2.3. Participant selection

All eligible patients had to have delirium for study entry. This particularity called for the use of surrogate consent to participate in research, during the time when the patient was temporarily inapt. This implied that a family caregiver had to consent for study entry, before consent could be confirmed with the patient after delirium.

2.3.1. Eligibility criteria

The inclusion criteria were (1) to present postsurgery delirium; (2) to have had either coronary artery bypass grafting (CABG) or heart valve surgery; (3) to have a family member present to consent within 24 hours after delirium onset; (4) to have no planned transfer to another hospital within the 3 days after delirium onset; (5) to have the preoperative cognitive ability to confirm the surrogate consent provided by the family caregiver after delirium resolution and speak and read French; (6) to have the potential of recovering full cognitive ability after surgery, for example, not presenting a diagnosis of delirium superimposed on dementia affecting cognitive abilities.

2.3.2. Selection of the sample

Assessment for eligibility was performed in 2 steps. Step 1 consisted of targeting patients who presented postoperative delirium (eligibility criteria 1). Step 2 was performed only among patients with delirium and consisted of assessing eligibility on the remaining criteria. The patient was entered in the study when his family caregiver gave consent during delirium, and once delirium had resolved, the patient's informed consent was obtained.

2.4. Variables and data measurement

2.4.1. Oximetry assessment

Assessments for oximetry using the Invos 5100 (COVIDIEN; Somanetics Corporation) were performed by the principal investigator (TM) trained by the anesthesiologist/intensivist investigator (AD).

Oximetry values were obtained using the INVOS 5100 device (COVIDIEN; Somanetics Corporation, Troy Michigan, USA). In the present study, 1 optode (Invos adult SomaSensors, COVIDIEN; Somanetics Corporation) was used per patient (the same for 3 days) and before each measuring sequence functioning of optodes was verified on the investigator's arm. After this, the optode was consecutively placed on 4 different sites on the forehead as represented by areas 1, 2, 3, and 4 of Fig. 1. Then, the optode was placed on 1 arm and 1 leg on either the right (5a and 6a on Fig. 1) or the left (5b and 6b on Fig. 1) side. On each site, the optode was left in place for 20 seconds or until signal stability, after which the value appearing on the device was retained. From the 6 oximetry values (4 cerebral, 1 arm, and 1 leg), we calculated 2 mean scores: a cerebral mean score based on the 4 sites on the forehead (1, 2, 3, and 4) and a peripheral score based on the 1 arm and the 1 leg (5a and 6a or 5b and 6b). These are treated as continuous variables.

2.5. Delirium assessment

2.5.1. Delirium screening in usual care

The ICDSC consists of an 8-item scale based on the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision*. The items include altered level of consciousness, inattention, disorientation, hallucination, psychomotor agitation or retardation, inappropriate speech or mood, sleep-wake cycle disturbance, and symptom fluctuation [4]. The score ranges from 0 to 8 [4]. The ICDSC sensitivity and specificity are, respectively, 0.94 and 0.64 [9]. In the research setting, the ICDSC is completed as part of usual care 3 times a day plus as needed. It is completed by bedside nurses when the patient's level of consciousness allows for assessment.

2.5.2. Delirium tools for hypothesis testing

In addition to the ICDSC and the medical diagnosis, 2 validated observational assessment tools were introduced for the present study,