CASE REPORT

Is baseline cerebral oximetry a better predictor than carotid scan for postoperative delirium in cardiac surgery?

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Guidelines recommend screening patients for carotid-artery stenosis, but unfortunately, measurement of baseline cerebral oximetry levels is still not a routine practice prior to cardiac surgery. We report a 41-year-old woman who presented with a normal carotid scan and unexpectedly low baseline cerebral oximetry levels. She had delayed postoperative recovery and discharge from hospital following her coronary-artery bypass surgery. This case report reiterates the prognostic significance of cerebral oximetry in the preoperative checkup and the association of low intraoperative values to postoperative cerebral impairment. It can also be identified as a comparatively better tool for preventing cognitive disturbances after cardiac surgery.

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Introduction

Guidelines recommend Doppler scan, as opposed to cerebral oximetry (rSO_2), as a routine test to detect carotid stenosis [1] prior to cardiac surgery. However, no studies have shown any correlation or superiority for Doppler scanning as a predictor for postoperative cognitive dysfunction. The current case report addresses the dilemma as to which parameter is considered better to predict postoperative delirium following cardiac surgery.

Case report

A 41-year-old female was scheduled for urgent coronary-artery bypass graft. A careful history was taken from her and from her relatives. Clinical examination did not reveal any occult

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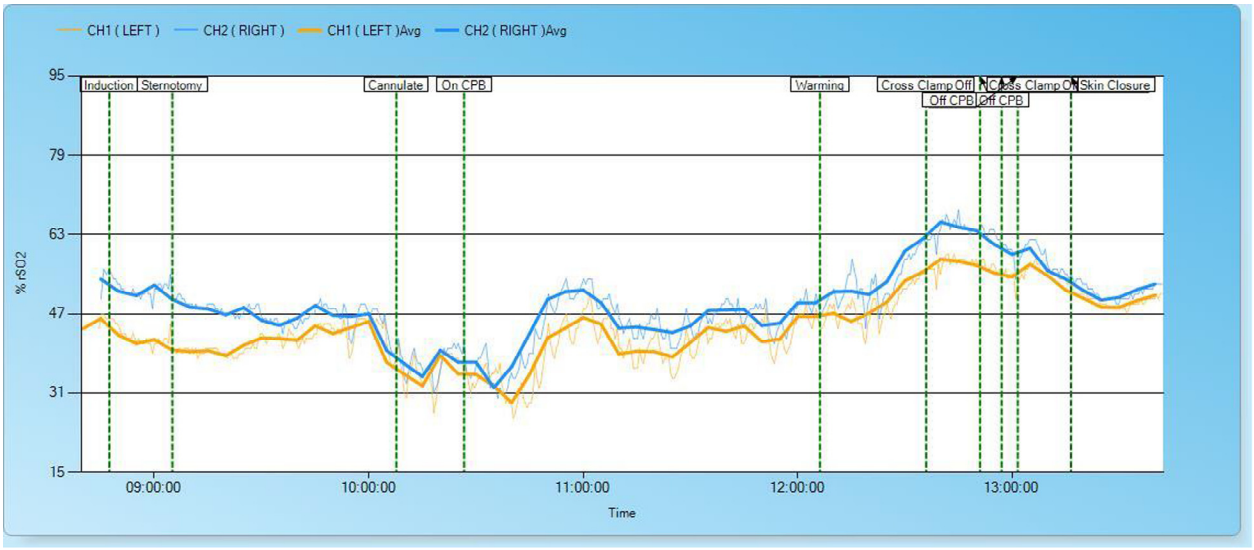

Figure 1. Recording of near-infrared spectroscopy using INVOS 5100 (Somanetics, Minneapolis, USA) showing variation in cerebral-oximetry readings during different stages of cardiac surgery. CPB = cardiopulmonary bypass; rSO_2 = cerebral oximetry.

neurological illness prior to operation. She was not overweight, was nondiabetic, and had a normal serum lipid profile. Consent for publication was obtained. Carotid scan did not reveal any significant stenosis. Following premedication with midazolam 7.5 mg, her baseline reading using the INVOS 5100 (Somanetics, Minneapolis, USA) in the operating room revealed rSO_2 levels of 44% on the right side and 51% on the left side. She had peripheral oxygen saturation of 97% with arterial oxygen tension 66 mmHg. She was preoxygenated using a well-fitting mask and closed anesthetic circle system using inspired oxygen concentration of 1 until the peripheral oxygen saturation reached closer to 100% to prevent any inadvertent hypoxia during induction and intubation. Despite stabilization of the signal, the baseline rSO_2 levels showed no improvement (Fig. 1).

The patient received a short-acting remifentanil/propofol-based anesthesia and cisatracurium for muscle paralysis. The mean arterial pressure was kept above 70 mmHg with low-dose norepinephrine infusion and phenylephrine boluses. Intraoperatively, a detailed transesophageal-echocardiography examination of the ascending aorta and the valves was performed by an experienced accredited echocardiographer to rule out any atheroma, as the patient had low baseline rSO_2 levels. She had good left ventricular function. Necessary steps in the event of cerebral desaturations were taken, which included [2] neutral head positioning, optimization of carbon dioxide, maintenance of arterial pressure, reevaluation of transfusion trigger, and optimization of cardiac performance and pump flow during cardiopulmonary bypass (CPB). CPB was established using cannulation of the ascending aorta and right atrium at a temperature of 32–34 °C. Heparin was used to maintain anticoagulation with nonpulsatile perfusion using a centrifugal pump and a membrane oxygenator filter of 40 µm was employed. A higher mean arterial pressure (MAP) of 60–65 mmHg was maintained on CPB, and if the rSO_2 levels decreased to less than 10% below the baseline, pressure on the pump was increased to maintain baseline rSO_2 levels. A three-vessel coronary-artery bypass graft was performed using the left internal thoracic artery and saphenous vein via median sternotomy. Total bypass and cross-clamp durations were 158 minutes and 95 minutes, respectively. Despite all the maneuvers (Fig. 1), the rSO_2 levels remained low on few occasions and showed a marginal improvement during weaning from the bypass machine. Anticoagulation was reversed with protamine and weaned off easily without inotropes, and the patient remained in sinus rhythm. Tranexamic acid (2 g) was administered as an antifibrinolytic, and estimated blood loss was 650 mL. Two units of packed cells were required to maintain hemoglobin levels above 10 g/dL.

Postoperatively, remifentanil/propofol sedation was continued until patient was warm and stable. Low-dose morphine infusion with supplemental diclofenac and paracetamol was started 3 hours following surgery. Morphine infusion was stopped after 10 hours, as the patient showed no response to verbal or painful stimuli. All her metabolic parameters were normal. Hemodynamic and other vital parameters were kept at preoperative

levels throughout the perioperative period. She had no clinical signs of infection or sepsis during the postoperative period that could have resulted in delirium. A computed tomography (CT) brain scan was performed after 48 hours, which showed no ischemic changes. Dexmedetomidine infusion was started on the third day, and she became agitated and was restless on the ventilator. She was extubated on the fourth postoperative day and remained delirious for the next 48 hours. We employed the confusion assessment method for the ICU (CAM-ICU) tool as a routine monitor to assess delirium, and the diagnosis of delirium was made by the intensive-care team. The patient was discharged to the ward on Day 8, and her remaining stay in the hospital was uneventful. She was fully coherent and mobile without any obvious clinical residual neurological dysfunction at the time of discharge from the hospital on the 14th day following surgery.

Discussion

Studies have shown that the atheroma load, hyperthermia, and new-onset atrial fibrillation have an increased risk of postoperative cognitive dysfunction [3], and to date near-infrared spectroscopy has been the only monitor advocated to detect cerebral ischemia during cardiac surgery. Heringlake et al. [4] have shown preoperative rSO_2 levels of 50% to be an independent risk factor for mortality, and the risk of delirium is high if the baseline is already low. However, these patients were elderly, severely ill, and had lower preoperative cognitive capacity. This study supports our patient except that she was relatively young, educated, with a normal carotid scan, and no major comorbidity. Her clinical examination and history did not reveal any additional risk factors like anxiety, depression, or hemoglobinopathies in the past that may have predisposed her to a postoperative delirium state. Furthermore, the incidence of significant carotid stenosis is very low, and the severity may not predict postoperative cerebrovascular accidents. Given the low rate of significant carotid-artery stenosis, its ability to predict the postoperative cerebrovascular events is uncertain [5]. Impaired cerebral microcirculation and lower oxygen content are possible explanations, and this subtle pathology may not be evident during a routine carotid scan. Interestingly, none of the variables, such as hemoglobin, proBNP, or the additive EuroSCORE, have been proved as a predictor of postoperative delirium. There is an association between rSO_2 levels and cognitive reserve, that allows certain patients to cope better than others, and subtle changes in oxygenation may disrupt this reserve leading to delirium [6]. Similar to previous reports, we had difficulty in maintaining the baseline rSO_2 levels despite best efforts. In addition, we have ruled out other predisposing factors, such as atheroma load by transesophageal echocardiography. We also prevented hyperthermia and postoperative atrial fibrillation during the perioperative period that may have resulted in a delayed recovery.

Currently, there are a few other technologies available apart from rSO_2, such as electroencephalogram, bispectral index, somatosensory evoked potential, and large artery cerebral-blood-flow velocity assessed by transcranial Doppler and carotid Doppler ultrasound. The application of electroencephalogram and evoked potentials requires specialized training, constant vigilance, and real-time interpretation. Detection failures have been detected during bispectral-index use in cardiac surgery [7]. Transcranial Doppler was found to be useful mainly in carotid and aortic surgeries [8] to improve the clinical outcome and hospital cost. As per our departmental policy, our patient received short-acting sedatives and regular oral analgesics that possibly reduced her opioid requirement for rapid recovery. We agree that the intraoperative surgical events could have been one of the reasons for the slow recovery, but the most evident factor was her unexpected low baseline and intraoperative rSO_2 levels that might be responsible for this morbidity.

The association of the rSO_2 levels with cerebral impairment makes an interesting tool for preventing cognitive disturbances after cardiac surgery. It is difficult to keep rSO_2 levels to their recommended levels as seen in our patient, because, as shown in other literature, patients can still develop postoperative delirium. In our institution, we use rSO_2 levels as a routine marker for monitoring cardiac surgical patients. Therefore, we were able to pick up on her low baseline cerebral saturation. This exercise may not be used in all centers if patients do not have significant preoperative neurological history, carotid bruit, or a significant finding in the carotid scan. In this case, the rSO_2 levels on each side were above the critical threshold during the operation, and there was no suspected cerebral ischemic event. Hemoglobin was kept above 10 g/dL as per the proposed algorithm developed by Denault et al. [9], as her baseline readings were borderline. She had only two units of blood transfused. However, we cannot rule out the possibility that the blood transfu-

sion may have been the cause of her delirium. It is also possible that our patient might have had a worse outcome had it not been detected by the routine use of rSO_2. Various approaches to optimize cerebral oxygenation, such as the use of positive inotropes and preoperative optimization of oxygen content, are in progress [10]. Further studies should be aimed to determine the optimal level of hemoglobin necessary to prevent cerebral hypoxia.

The use of rSO_2 to guide intraoperative management has been shown to improve patient outcomes in cardiac surgery. However, it is important to note that rSO_2 is considered as a regional monitor, which detects changes in the anterior circulation of the cerebral hemisphere. This should be taken into consideration during data interpretation and decision making. The neurologist recommended her to have further neurological tests, including CT brain/neck angiography 3 months following the operation. Unfortunately, she could not be followed up in our institution, as she was a visitor to the country. The CT chest to detect aortic calcification and a repeat cerebral oximetry test prior to discharge would have added further value to our initial findings.

There is currently no evidence of harm related to near-infrared-spectroscopy-guided interventions other than cost. It is about time that we recognize the implication of this technology and make its use available as a preoperative tool. This will help to identify delirium-susceptible patients early and to optimize them with a view to reduce postoperative delirium following cardiac surgery.

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