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# Determinants and significance of cerebral oximetry after cardiac arrest: A prospective cohort study

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ABSTRACT

*Aim of the study:* To study the determinants and the evolution of cerebral oximetry determined by near-infrared spectroscopy after out-of-hospital cardiac arrest of cardiac origin during therapeutic hypothermia and rewarming, and to compare cerebral oximetry values between patients with good and bad prognosis.

*Methods:* In this prospective, non-interventional, single center study, all consecutive patients between 18 and 80 years admitted for out-of-hospital cardiac arrest (OHCA) with a no flow less than 10 min, a low flow of less than 50 min and a persistent coma after ROSC with Glasgow score equal or less than seven at baseline were included.

*Results:* Between February 2012 and January 2013, 43 patients were admitted for OHCA in our ICU. Twenty-two patients (51%) were discharged with no or minimal neurologic complications (CPC 1–2). Mortality rate in the ICU was 46.5%. Cerebral oximetry ($rSO_2$) was correlated with temperature, heart rhythm, $PaO_2$, hemoglobin, and mean arterial pressure. Mean $rSO_2$ during the 48 first hours was not different between patients with good and bad neurologic outcomes, respectively, 61.8 (5.9) vs. 58.1 (8.8), $P = 0.13$, as during the period of hypothermia. The minimal value of $rSO_2$ during the first 48 h was significantly different between patients with good prognosis and those with bad prognosis, respectively, 45.0 (6.8) vs. 31.7 (15.0), $P = 0.0009$.

*Conclusions:* In this prospective cohort of OHCA patients, main determinants of $rSO_2$ were systemic variables. Monitoring of $rSO_2$ does not allow discriminating patients with good or bad outcome, but could be useful for identifying vulnerable periods for the development of neurologic injury.



## Introduction

Out-of-hospital cardiac arrest (OHCA) is associated with high morbidity and mortality and is still a major issue for public health. Even when a return of spontaneous circulation (ROSC) is obtained, the vast majority of these patients will die during the post-resuscitation period, mostly because of irreversible hypoxic-ischaemic brain injury.[1] Evaluating the severity of brain damages is very difficult at the very early period and is hindered by therapeutics used at hospital admission, such as hypothermia and sedative drugs. At that time, there is no single predictive factor that can early identify patients with a bad outcome.[2,3] A delayed multimodal prognostication approach is usually recommended in comatose patients but an earlier identification of those with no chance of recovery will help to avoid inappropriate treatment and provide information for relatives.

With the exception of hypothermia, no treatment has demonstrated its ability to reduce the impact of global cerebral ischemia induced by cardiac arrest. This reflects the lack of knowledge on the pathophysiology of the post anoxic encephalopathy, especially in the early phase of resuscitation and during hypothermia. Cerebral oxygen extraction and consumption monitored by jugular venous oxygen saturation ($SVjO_2$) are critical determinants of neurologic

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recovery after cardiac arrest.[4–7] However, these tools are invasive, time-consuming, and laborious in a non-neurosurgical environment. Near-infrared spectroscopy (NIRS) is a non-invasive optical technique based on the transmission and absorption of NIR light as it passes through tissues. NIRS provides real-time information regarding regional cerebral oxygen saturation ($rSO_2$) in the frontal lobe. Correlation between $rSO_2$ and $SVjO_2$ is inconstant through studies and clinical situations. Hence this correlation was found to be excellent during cardiac surgery,[8] but insufficient to recommend its clinical use after traumatic brain injury.[9,10] Despite these conflicting results, NIRS was demonstrated to be a useful tool to monitor cerebral oxygenation[11,12] and autoregulation[13] under cardiopulmonary bypass for cardiac surgery. Cerebral oximetry can provide real-time information on oxygen delivery during resuscitation in in-hospital cardiac arrest patients,[14,15] and first $rSO_2$ measured at hospital arrival was demonstrated to predict neurological outcome after out-of-hospital cardiac arrest.[16] Few studies investigated the feasibility and the utility of NIRS after return of spontaneous circulation. Among them, two studies[17,18] showed a statistically significant difference of $rSO_2$ between patients with good and neurologic prognosis, but the small numbers of patients included as well as the few available data on other physiological variables limit their interpretability. Cerebral oximetry could be an additional tool in the prediction of neurological prognosis after cardiac arrest, but more data about its interpretability are needed. Hence, we perform a prospective, descriptive study of $rSO_2$ and its components after ROSC, and during therapeutic hypothermia.

## Material and methods

### *Study setting and patients*

This was a prospective, observational, and single center study. Between February 2012 and January 2013, all consecutive patients admitted for OHCA were studied. Patients had to be aged between 18 and 80 years, and cardiac arrest had to meet the following characteristics:

an OHCA of cardiac origin;
a delay from collapse to basic life support less than 10 min ("no flow");
a delay from basic life support to return of spontaneous circulation (ROSC) of less than 50 min ("low flow");
a persistent coma after ROSC with Glasgow score equal or less than seven at baseline;

The exclusion criteria were a non-cardiac OHCA (trauma, sepsis, acute respiratory failure or acute neurologic disorder) and any chronic brain disease. The study protocol was approved by the committee for medical ethics of the French intensive care society (CE SRLF 11–353).

### *Patient's management*

Out-of-hospital resuscitation was performed by an emergency team, including at least one trained physician in emergency medicine, according to international guidelines.[19] Patients in whom the resuscitation process failed were not transported to hospital. According to our previously published procedures,[20,21] patients in whom sustained ROSC was achieved, and without obvious extra-cardiac cause were admitted directly to the catheterization laboratory of our tertiary center, to perform a coronary angiogram, and a left ventricular angiography using standard techniques. A percutaneous coronary intervention was attempted if there was an acute coronary artery occlusion, or if there was an unstable lesion that could be considered as the culprit. After the procedure, patients were admitted to the intensive care unit (ICU) for supportive treatment, which systematically included targeted temperature management between 32 and 34 degrees Celsius. This treatment was instaured for a 24 h period as described in previous works.[22] In cases with obvious extra-cardiac cause, patients were immediately admitted to ICU to promptly benefit of adequate treatment. All patients received a standardized treatment protocol aiming to limit the worsening of brain damages, as previously described.[1,20,23]

### *Cerebral oximetry*

Monitoring of cerebral oximetry ($rSO_2$) is part of standard care in our ICU for OHCA patients using NIRS. A sensor was used and put on the right temporal area as described by the manufacturer (Somanetics INVOS, Covidien, Boulder, CO, USA). The monitoring was started as soon as possible after ICU admission and was maintained during the first 48 h. Physician and nurses in charge checked the quality of the signal every 3 h to ensure an adequate monitoring. Data were registered in the device and extracted on day three for subsequent analysis.

### *Data's management*

Physiological values were recorded continuously during the whole period of the study. Heart rate (HR), respiratory frequency, mean arterial pressure (MAP), pulse oximetry, body's core temperature, and cerebral oximetry were extracted simultaneously every hour and entered in our database. Values from arterial blood samples (hemoglobin, $PaO_2$, and $PaCO_2$) were added to the corresponding time. Frequency of this sample was every 6 h and was part of our routine care in post cardiac arrest management. This frequency could be higher if patients were unstable.

### *Outcome assessment*

The primary outcome was defined as the level reached on the cerebral performance categories scale (CPC) at hospital discharge.[24] Favorable outcome included patients with a good cerebral performance (CPC level 1), or a moderate cerebral disability (CPC2). Bad outcome was defined by a severe cerebral disability (CPC3), a coma or a vegetative state (CPC4), or death (CPC5). The CPC level was prospectively assessed by a first physician at hospital discharge and was controlled by a second and independent physician blinded for post-resuscitation treatments. Each case of disagreement was resolved by a consensus. Neurological outcome was daily assessed by ICU physicians until death or ICU discharge. According to guidelines and recent studies[25–28] life-sustaining treatments were withdrawn in case of absence of pupillary responses, absence of corneal reflexes, absent or extensor motor responses, and bilateral absence of the N20 component of the somatosensory evoked potentials with median nerve stimulation. As all patients were treated by therapeutic hypothermia, this neurological assessment was systematically delayed at minimum on day five after OHCA in order to wait for elimination of sedative drugs. Life-sustaining therapies withdrawal was always decided after a collegial decision.[1]

### *Statistical analysis*

This report was prepared in compliance with the STROBE checklist for observational studies.[29] Continuous variables were presented as mean ± standard deviation, and categorical variables were presented as percentages. Comparisons between groups (according to neurological outcome, with CPC 1–2 considered as good outcome) were made with Pearson $X^2$ or Fisher's exact tests