



Clinical Paper

Characteristics of regional cerebral oxygen saturation levels in patients with out-of-hospital cardiac arrest with or without return of spontaneous circulation: A prospective observational multicentre study[☆]



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ABSTRACT

Aim: Our study aimed at filling the fundamental knowledge gap on the characteristics of regional brain oxygen saturation (rSO₂) levels in out-of-hospital cardiac arrest (OHCA) patients with or without return of spontaneous circulation (ROSC) upon arrival at the hospital for estimating the quality of cardiopulmonary resuscitation and neurological prognostication in these patients.

Methods: We enrolled 1921 OHCA patients from the Japan – Prediction of Neurological Outcomes in Patients Post-cardiac Arrest Registry and measured their rSO₂ immediately upon arrival at the hospital by near-infrared spectroscopy using two independent forehead probes (right and left). We also assessed the percentage of patients with a good neurological outcome (defined as cerebral performance categories 1 or 2) 90 days post cardiac arrest.

Results: After 90 days, 79 (4%) patients had good neurological outcomes and a median lower rSO₂ level of 15% (15–20%). Compared to patients without ROSC upon arrival at the hospital, those with ROSC had significantly higher rSO₂ levels (56% [39–65%] vs. 15% [15–17%], respectively; $P < 0.01$), and significantly correlated right- and left-sided regional brain oxygen saturation levels ($R = 0.94$ vs. 0.66, respectively). In both groups, the percentage of patients with a good 90-day neurological outcome increased significantly in proportion to their rSO₂ levels upon arrival at the hospital ($P < 0.01$).

Conclusion: Our data indicate that measuring rSO₂ levels might be effective for both monitoring the quality of resuscitation and neurological prognostication in patients with OHCA.

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1. Introduction

Recent guidelines for cardiopulmonary resuscitation (CPR) increased the focus on methods ensuring that high-quality CPR is performed in all resuscitation attempts.^{1,2} A reliable, inexpensive, non-invasive physiological monitor that will increase our ability to optimize CPR for individual patients of cardiac arrest should be developed. This is necessary to advance the delivery of optimal CPR and ultimately save more lives.^{3–5}

On the other hand, the advent of systematic bundled post-cardiac arrest interventions (PCaIs) has increased the likelihood of patients surviving out-of-hospital cardiac arrests (OHCAs) while maintaining good neurological conditions.^{6–11} Hence, the importance of estimating the severity of brain damage and the neurological prognostication for OHCA patients has been emphasized in the literature.^{6,9,10,12,13}

Regional cerebral oxygen saturation (rSO₂) is a measure of cerebral perfusion that is obtained noninvasively via near-infrared spectroscopy (NIRS) and can be monitored in patients with cardiac arrest.^{14–18} We previously reported that rSO₂ measured upon the patient's arrival at the hospital might help to predict neurological outcomes in OHCA patients.^{19,20} The optimal cut-off point identified in our study was an rSO₂ >42%. These data suggest that rSO₂ monitoring might be useful for (1) monitoring the quality of CPR for patients before the return of spontaneous circulation (ROSC), and (2) determining a neurological prognostication for all OHCA patients.

When continuous rSO₂ monitoring of patients undergoing pre-hospital CPR is performed,²¹ rSO₂ values of patients with and without ROSC have to be assessed. This will likely cause some confusion regarding which rSO₂ values (those during the resuscitation state vs. those post resuscitation) should be adopted for prognostication and precise triage to PCaIs. To establish methods for quality monitoring of resuscitation and neurological prognostication, rSO₂ levels might therefore have to be interpreted according to ROSC status in patients with and without ROSC on arrival at the hospital.

Achieving ROSC after an OHCA has a significant effect on cerebral circulation and oxidation. Using receiver operating characteristic analyses, our previous report demonstrated the different optimal cut-off points for predicting good neurological outcomes between OHCA patients with and without ROSC upon arrival at the hospital (rSO₂ >62% and >21%, respectively).¹⁹ However, few studies have focused on how ROSC upon arrival at the hospital affects rSO₂ monitoring and sensitivity for the neurological prognostication after an OHCA.

To address this knowledge gap, we conducted a descriptive study aimed at performing a precise comparison of rSO₂ values in patients undergoing resuscitation and those post resuscitation upon arrival at the hospital.

2. Methods

2.1. Study design and setting

The Japan – Prediction of Neurological Outcomes in Patients Post-cardiac Arrest Registry (J-POP) is a prospective multicentre

cohort study. Fifteen tertiary emergency care hospitals in Japan participated in this study from 15 May 2011 to 30 August 2013. Among the consecutive 3086 OHCA patients who were transported to the hospitals, 1921 patients were enrolled in the study. Individuals who were unresponsive during and after resuscitation upon arrival at the hospital following an OHCA were included in our study. The exclusion criteria included trauma, accidental hypothermia, age <18 years, completion of the “Do Not Attempt Resuscitation” form, and a Glasgow coma scale (GCS) score of >8 upon arrival at the hospital.

The study protocol was approved by the institutional review board or ethics committee at each participating hospital. The details of the J-POP registry design and its main outcomes have been published elsewhere.¹⁹

2.2. Emergency medical services and cardiopulmonary resuscitation in Japan

In Japan, emergency lifesaving technicians are permitted to insert tracheal tubes and administer intravenous adrenaline (epinephrine).²² All emergency medical service (EMS) providers perform CPR according to current CPR guidelines.^{2,23} However, EMS providers are not permitted to terminate CPR in the field.

2.3. Resuscitation procedures after arrival at the hospital

All patients received advanced life support in accordance with the national guidelines for resuscitation after arrival at the emergency department. If sustained ROSC (restoration of a palpable pulse that is sustained for at least 20 min) was not obtained using standard advanced life support, patients whose initially documented electrocardiograph rhythm was ventricular fibrillation or pulseless ventricular tachycardia received extracorporeal CPR with extracorporeal circulatory support or a cardiopulmonary bypass. When patients achieved ROSC, therapeutic hypothermia was induced once their systolic blood pressure exceeded 90 mmHg and their GCS score was between 3 and 8.^{24–26} All procedural decisions were made at the discretion of the attending physician(s).

2.4. Patient characteristics and cardiac arrest

Data were collected prospectively based on the Utstein style.^{27,28} Baseline patient characteristics and in-hospital data were collected from medical records and databases.¹⁹

Cardiac arrest was defined as the absence of spontaneous respiration, a palpable pulse, and stimuli responsiveness.^{27–29} The arrest was presumed to be of cardiac origin unless it was caused by cerebrovascular disease, respiratory disease, external factors (e.g., drug overdose or asphyxia), or other non-cardiac factors. Cardiac or non-cardiac origin was determined clinically by the physician-in-charge.

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