



## Clinical paper

## Regional cerebral oxygen saturation monitoring for predicting interventional outcomes in patients following out-of-hospital cardiac arrest of presumed cardiac cause: A prospective, observational, multicentre study<sup>☆</sup>



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## ABSTRACT

**Aim:** This study investigated the value of regional cerebral oxygen saturation (rSO<sub>2</sub>) monitoring upon arrival at the hospital for predicting post-cardiac arrest intervention outcomes.

**Methods:** We enrolled 1195 patients with out-of-hospital cardiac arrest of presumed cardiac cause from the Japan-Prediction of Neurological Outcomes in Patients Post-cardiac Arrest Registry. The primary endpoint was a good neurologic outcome (cerebral performance categories 1 or 2 [CPC1/2]) 90 days post-event.

**Results:** A total of 68 patients (6%) had good neurologic outcomes. We found a mean rSO<sub>2</sub> of 21% ± 13%. A receiver operating characteristic curve analysis indicated an optimal rSO<sub>2</sub> cut-off of ≥40% for good

**Abbreviations:** AUC, area under the curve; CAG, coronary angiography; CI, confidence interval; CPC, Glasgow–Pittsburgh cerebral performance category; CPR, cardiopulmonary resuscitation; GCS, Glasgow Coma Scale; J-POP, Japan-Prediction of Neurological Outcomes in Patients Post-Cardiac Arrest; OHCA, out-of-hospital cardiac arrest; PCAI, post-cardiac arrest intervention; PCI, percutaneous coronary intervention; ROC, receiver operating characteristic; ROSC, return of spontaneous circulation; rSO<sub>2</sub>, regional cerebral oxygen saturation; TH, therapeutic hypothermia.

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Cardiac arrest  
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neurologic outcomes (area under the curve 0.92, sensitivity 0.81, specificity 0.96). Good neurologic outcomes were observed in 53% (55/103) and 1% (13/1092) of patients with high ( $\geq 40\%$ ) and low ( $< 40\%$ )  $rSO_2$ , respectively. Even without return of spontaneous circulation (ROSC) upon arrival at the hospital, 30% (9/30) of patients with high  $rSO_2$  had good neurologic outcomes. Furthermore, 16 patients demonstrating ROSC upon arrival at the hospital and low  $rSO_2$  had poor neurologic outcomes. Multivariate analyses indicated that high  $rSO_2$  was independently associated with good neurologic outcomes (odds ratio = 14.07,  $P < 0.001$ ). Patients with high  $rSO_2$  showed favourable neurologic prognoses if they had undergone therapeutic hypothermia or coronary angiography (CPC1/2, 69% [54/78]). However, 24% (25/103) of those with high  $rSO_2$  did not undergo these procedures and exhibited unfavourable neurologic prognoses (CPC1/2, 4% [1/25]).

**Conclusion:**  $rSO_2$  is a good indicator of 90-day neurologic outcomes for post-cardiac arrest intervention patients.

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## Introduction

The advent of systematic bundled post-cardiac arrest interventions (PCAI) has increased the likelihood of patients surviving with good neurologic function after out-of-hospital cardiac arrests (OHCA).<sup>1,2</sup> In particular, therapeutic hypothermia (TH) and percutaneous coronary intervention (PCI) with emergent coronary angiography (CAG) have been reported to improve the prognoses of patients following OHCA of presumed cardiac cause.<sup>2–4</sup>

On the other hand, recent studies have shown that TH does not provide a beneficial effect following OHCA.<sup>5,6</sup> In fact, brain damage severity estimations and outcome prognoses for OHCA patients were found to be inaccurate,<sup>7,8</sup> implying that stratification before or imbalance corrections after randomisation might have been problematic in many previous studies. Additionally, the absence of appropriate measurements for brain damage severity estimations and prognosis determinations might make it difficult to perform stratified randomisations in clinical trials involving patients experiencing OHCA of presumed cardiac cause.<sup>9</sup> Thus, better prognostic factors are needed to elucidate ‘true indications’ of PCAI outcomes following such events.

Regional cerebral oxygen saturation ( $rSO_2$ ) is a measure of cerebral perfusion that is obtained noninvasively via near-infrared spectroscopy and monitored in patients during cardiac arrest since the instrument does not require vascular pulsation.<sup>10,11</sup> We previously reported that  $rSO_2$ , measured upon arrival at the hospital, might help predict neurologic outcomes in patients following OHCA.<sup>12</sup> However, few studies have focused on whether  $rSO_2$  measurements are effective for estimating brain damage severity, for determining prognoses, or in the decision-making process for PCAI in patients who have experienced OHCA of presumed cardiac cause.<sup>13</sup> Therefore, this study aimed to evaluate the clinical usefulness of  $rSO_2$  monitoring to estimate the severity of brain damage and determine the prognoses of patients following OHCA of presumed cardiac causes.

## Methods

### Study design and setting

The Japan-Prediction of Neurological Outcomes in Patients Post-cardiac Arrest (J-POP) Registry is a prospective multicentre cohort study, and 15 Japanese tertiary emergency care hospitals participated in the J-POP during the study period (15 May 2011 to 30 August 2013). The inclusion criterion was unresponsiveness during and after resuscitation upon arrival at the hospital following an OHCA. The exclusion criteria included (1) trauma, (2) accidental hypothermia, (3) age  $< 18$  years, (4) completion of the ‘Do Not Attempt Resuscitation’ form, and (5) a Glasgow coma scale (GCS) score  $> 8$  upon arrival at the hospital. The details of the

J-POP registry design and main outcomes have been published elsewhere.<sup>12</sup>

To identify the value of emergency room  $rSO_2$  measurements in the PCAI (including TH and CAG) decision-making process, we analysed 1195 consecutive patients with OHCA of presumed cardiac cause from the J-POP registry.

### Emergency medical care in Japan

In Japan, emergency lifesaving technicians are permitted to insert tracheal tubes and administer intravenous adrenaline (epinephrine).<sup>14</sup> All emergency medical service providers perform cardiopulmonary resuscitation (CPR) according to the current CPR guidelines.<sup>15,16</sup> However, the providers are not permitted to terminate CPR in the field.

### Procedures after arrival at the hospital

All patients received advanced life support in accordance with national guidelines. If sustained return of spontaneous circulation (ROSC), i.e. the restoration of a palpable pulse that is sustained for at least 20 min, was not obtained using standard advanced life support, patients with initially documented ventricular fibrillation or pulseless ventricular tachycardia received extracorporeal CPR and extracorporeal circulatory support or a cardiopulmonary bypass. If patients obtained sustained ROSC, TH was induced once their systolic blood pressure exceeded 90 mmHg and their GCS score was 3–8.<sup>5,17,18</sup> All procedural (e.g., extracorporeal CPR, CAG, PCI, and TH) and diagnostic decisions were made at the discretion of the attending physician(s).

### Data collection

Data were prospectively collected according to the Utstein style.<sup>19,20</sup> Baseline patient characteristics and in-hospital data were collected from medical records and databases.

Cardiac arrest was defined as the absence of spontaneous respiration, a palpable pulse, and stimuli responsiveness.<sup>19</sup> The arrest was presumed to be of cardiac origin unless it was due to cerebrovascular disease, respiratory disease, external factors (e.g., drug overdose or asphyxia), or other non-cardiac factors.

### Near-infrared spectroscopy

Upon arrival at the hospital, 2 disposable near-infrared spectrometer (INVOS™ 5100C; Covidien, Boulder, CO, USA) probes were carefully applied to both sides of the patient’s forehead. After several seconds of stabilisation,  $rSO_2$  was monitored using the probes for at least 1 min, and the lowest  $rSO_2$  reading was recorded.<sup>11,12,21</sup>

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