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Clinical paper

A feasibility study evaluating the role of cerebral oximetry in predicting return of spontaneous circulation in cardiac arrest☆

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ABSTRACT

To date there has been no reliable noninvasive real time monitoring available to determine cerebral perfusion during cardiac arrest.

Objectives: To investigate the feasibility of using a commercially available cerebral oximeter during in-hospital cardiac arrest, and determine whether this parameter predicts return of spontaneous circulation (ROSC).

Methods: Cerebral oximetry was incorporated in cardiac arrest management in 19 in-hospital cardiac arrest cases, five of whom had ROSC. The primary outcome measure was the relationship between rSO_2 and ROSC.

Results: The use of cerebral oximetry was found to be feasible during in hospital cardiac arrest and did not interfere with management. Patients with ROSC had a significantly higher overall mean ± SE rSO_2 (35 ± 5 vs. 18 ± 0.4, $p < 0.001$). The difference in mean rSO_2 between survivors and non-survivors was most pronounced in the final 5 min of cardiac arrest (48 ± 1 vs. 15 ± 0.2, $p < 0.0001$) and appeared to herald imminent ROSC. Although spending a significantly higher portion of time with an $rSO_2 > 40\%$ was found in survivors ($p < 0.0001$), patients with ROSC had an rSO_2 above 30% for >50% of the duration of cardiac arrest, whereas non-survivors had an rSO_2 that was below 30% > 50% of their cardiac arrest. Patients with ROSC also had a significantly higher change in rSO_2 from baseline compared to non-survivors (310% ± 60% vs. 150% ± 27%, $p < 0.05$).

Conclusion: Cerebral oximetry may have a role in predicting ROSC and the optimization of cerebral perfusion during cardiac arrest.

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1. Introduction

There are currently no non-invasive real time methods routinely used during cardiac arrest to determine cerebral perfusion. Cerebral oximetry by near infrared spectroscopy (NIRS) is a non-invasive optical monitoring technique that assesses regional cerebral oxygen saturation (rSO_2) and provides a real time indicator of the balance between oxygen supply and demand.[1] Even though this technology has been validated and used extensively as a tool for cerebral perfusion monitoring in many clinical scenarios,[2–4] to date there have only been very limited studies utilizing cerebral oximetry during cardiac arrest.[5,6] These studies have indicated that this technique may have a role in measuring rSO_2 and correlating with outcomes in out of hospital cardiac arrest. The aim of this study was to determine if cerebral O_2 saturation measured by cerebral oximetry during in-hospital cardiac arrest was associated with ROSC.

2. Methods

Cerebral oximetry using near infrared spectroscopy (NIRS) (Invos Somanetics, Troy, USA) was incorporated as a non-invasive marker of cerebral perfusion during in-hospital cardiac arrest for the purpose of clinical evaluation. This technique provides an index of changes in regional brain hemoglobin oxygen saturation over time (lower limit of detection 15%).[1] Each sensor consists of an adhesive strip, a near-infrared light transmitter and two sensors. The emitted light is scattered by tissues in two parabolic curves, one corresponding with hemoglobin saturation from the skin and skull, and the other from the skin, skull, and frontal cortex.[1] Using specific algorithms the hemoglobin saturation in the surface of the frontal cortex is calculated.[1] These data mainly represent cerebral venous saturation; generally acceptable normal values for rSO_2 are in the range of 60–80%.[7] A sensor was placed on each patient's forehead and monitoring was carried out continuously until either ROSC was achieved or CPR was terminated. The primary outcome was ROSC

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lasting more than 20 min. In order to determine the optimal rSO_2 read out the following parameters were analyzed: (1) mean and median rSO_2, (2) overall rSO_2 change from baseline, (3) mean and median rSO_2 in the 5 min prior to ROSC or termination of CPR (as a potential predictor of ROSC) and (4) the proportion of time spent in different categories of rSO_2 (<20%, 21–30%, 31–40%, 41–50% and >51%) during cardiac arrest.

2.1. Ethical considerations

All patients received the standard of care available at the hospital without experimental interventions. After consultation with the institutional review board (IRB) it was deemed that this study cannot be classified as research since the use of oximetry was carried out for the purpose of clinical evaluation and that this paper represents a case series. Staff had no insight regarding neither the cerebral oximetry device nor the interpretation of the rSO_2 values. It was not used to alter management.

2.2. Statistical analysis

Descriptive statistics were used for all continuous rSO_2 measurements and expressed as either mean or median ± SE. The Mann–Whitney test was utilized for comparison of survivor and non-survivor data. Survival was defined as return of spontaneous circulation for greater than 20 min. Statistical analyses were performed using PRISM Version 6 (GraphPad, USA).

3. Results

19 cardiac arrest patients were monitored using cerebral oximetry. ROSC was achieved in 21% ($n = 5$). The average age ± SD of survivors was 76 ± 15 and non-survivors 73 ± 11. All survivors had pulseless electrical activity (PEA) as their initial rhythm. 11 of 14 non-survivors had PEA, 2 had asystole and one ventricular fibrillation. The use of cerebral oximetry did not interfere with care. The data from 4 of the 14 non-survivors was not included, because the oximeter either did not register any rSO_2 values or varied between one reading of 15% and no subsequent readings, possibly suggesting that actual values may have been below the lower limit of measurement threshold (15%). Thus data was compared between 5 survivors and 10 non-survivors. There was no difference in the duration of resuscitation between survivors and non-survivors (19 ± 4 vs. 15 ± 5, $p > 0.05$). Placement of the sensor on either the right or left side of the forehead took an average of approximately 15 (±10) s. CPR was not stopped during this process. On arrival at the scene of cardiac arrest (with one exception) rSO_2 measurements were low (15–21%). Patients with ROSC had a significantly higher overall mean ± SE rSO_2 (35 ± 5 vs. 18 ± 0.4, $p < 0.001$) (Fig. 1a). This difference in rSO_2 was higher in the final 5 min of resuscitation (48 ± 1 vs. 15 ± 0.2, $p < 0.0001$) and appeared to predict the imminent onset of ROSC (Fig. 1b). The gradual rather than sudden increase in rSO_2 noted in response to CPR in survivors as evidenced by the change from a low baseline (<21%), to an overall mean of 35 ± 5 and 48 ± 1 in the final 5 min, suggests that this increase was not due to a sudden resumption of cardiac output. Although in some studies the median has been utilized, analysis of our results did not demonstrate a significant difference between values derived using the mean or median (data not shown). Statistically significant differences were noted in terms of the relative proportion of time spent in the <20%, 41–50% and >51% categories of rSO_2 between survivors and non-survivors (Fig. 2a). Although spending a significantly higher portion of time with an $rSO_2 > 40\%$ strongly predicts survival ($p < 0.0001$), it was also noted that whereas patients with ROSC had rSO_2 levels above 30% for the majority of their cardiac arrest, non-survivors had an $rSO_2 \leq 30\%$ for the majority of their cardiac arrest ($p < 0.001$) (Fig. 2b). Patients with ROSC had a significantly higher change in rSO_2 from baseline (15–21%) compared to non-survivors (310% ± 60% vs. 150% ± 27%, $p < 0.05$) (Fig. 3). In this small sample a mean rSO_2 value of 48% during a 5 min period of resuscitation has a positive predictive value of 1.0 for ROSC.

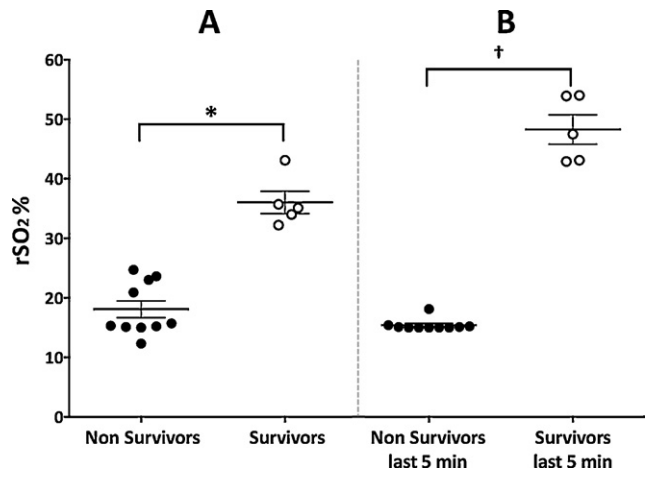

Fig. 1. The relationship between return of spontaneous circulation (ROSC) and rSO_2 expressed as mean ± SE over (A) the entire duration of cardiac arrest and (B) in the final 5 min of resuscitation. *$p < 0.001$ and †$p < 0.0001$ using Mann–Whitney test.

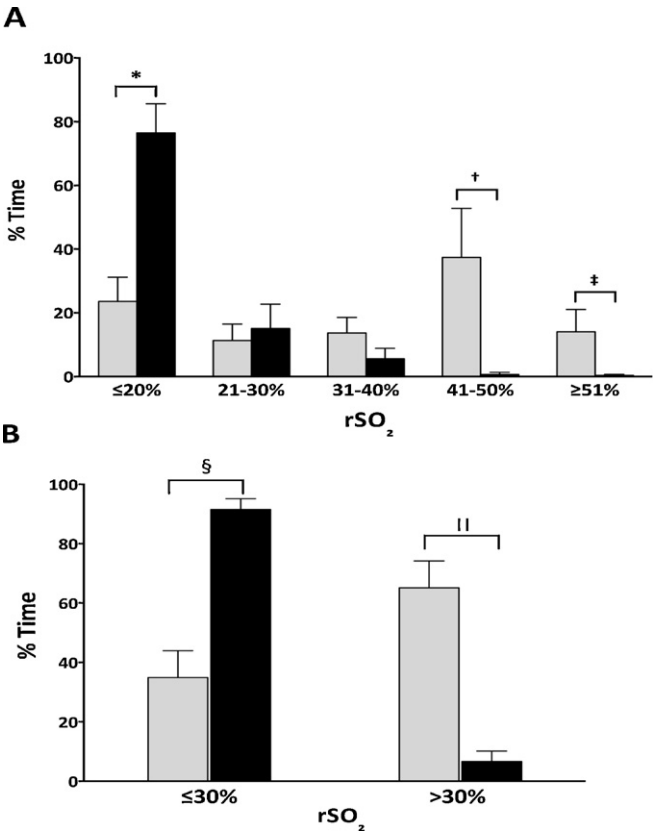

Fig. 2. (A) The relative proportion of time spent during cardiac arrest (expressed as % time) in the different categories of rSO_2 in survivors (white) and non-survivors (black) *$p < 0.01$, †$p < 0.0001$ ‡$p < 0.05$. (B) The proportion of time spent with an rSO_2 above and below 30% in survivors (white) and non-survivors (black) §$p < 0.001$, ||$p < 0.0005$ using Mann–Whitney test.