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How near is near infrared spectroscopy in pre-hospital care?

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Maintaining an adequate cerebral oxygenation appears intuitively as a crucial goal for the acute care of the critically injured patient¹. The concept of avoiding secondary brain injury represents a corner stone of modern neurointensive care and these principles should ideally be applied also during the pre-hospital phase and patient transport. Delivery of oxygen to the brain is governed by the cerebral perfusion pressure largely determined by mean arterial blood pressure (in the absence of significant intracranial hypertension) and the arterial blood oxygen content, partly reflected by peripheral pulse oximetry¹. Thus, the arterial blood pressure and oxygen saturation have formed the standard clinical endpoints to support cerebral oxygenation given the paucity of methods to monitor brain perfusion, that when available are too complex for use in the austere prehospital environment².

Near-infrared spectroscopy (NIRS) has been studied as a method to monitor cerebral tissue oxygenation and to possibly detect cerebral ischaemia, but has thus far not been commonly established in hospital clinical routine³. Very limited data exist regarding the application of NIRS in the prehospital setting⁴. The collection of reliable and preferably continuous data is challenging for most monitoring devices in the prehospital environment and certainly so for elaborate techniques such as NIRS. In this issue of *Acta Anaesthesiologica Scandinavica*, Weatherall and colleagues report preliminary feasibility data from a prospective observational study on the use of continuous NIRS monitoring during retrieval of trauma patients⁵. The NIRS sensors were applied by a dedicated researcher who was not part of the clinical team to the forehead bifrontally and to one forearm, unless precluded by haematomas or lacerations. These anatomical sites for NIRS have been studied fairly extensively in the in-hospital setting. The authors report that the quality of the NIRS monitoring was acceptable for more than 70% of the prehospital time in 45/63 patients for all sensor sites and in 57/63 patients for at least two sensor sites. Introducing NIRS monitoring did not prolong the on scene or transport times, with the caveat that additional study personnel was utilized. The authors are to be commended on undertaking this study within the logistical constraints of prehospital emergency care and for their transparent presentation of results, including important limitations.

The authors used a threshold value of 70% for an adequate NIRS signal to assess feasibility. This cut-off appears appropriate and would certainly allow for the determination of cerebral oximetry trends, both as driven by the trauma induced pathology and responses to therapeutic interventions. A sensitivity analysis of using a higher threshold was not performed. Inferences made in the text to monitoring of cerebral autoregulation warrant circumspection as both arterial pressure and NIRS signals would need to be captured with appropriate, contemporaneous quality. Playing the devil's advocate, one could argue that the signal acquisition per se does not equate to meaningful information, as provocatively demonstrated by Kahn et al⁶. Conversely, changes in the NIRS signal were recently reported to reflect physiological changes determining the NIRS reading⁷. Does the feasibility to capture a NIRS signal pre-hospitally lead to the monitoring fallacy that we make important what we can measure rather than measuring what is important? The study was not designed to capture any associations with patient centered outcomes and this limitation is clearly acknowledged by the authors. The rapid physiological changes seen in the unstable trauma patient, in whom NIRS could provide very useful information, might also challenge

the inherent and proprietary algorithms used to derive the tissue oxygenation signal, including the volume partition between arterial and venous vascular compartments. It is important to remember that different NIRS devices perform differently, in particular the ability to measure tissue oxygenation in the extreme low range. Thus, the results of this study need to be confirmed using other devices. Establishing the feasibility of NIRS monitoring is obviously a sine qua non for any further studies investigating clinical associations or interventions targeting management of blood pressure or haemoglobin, oxygen and carbon dioxide levels that all may influence NIRS^{8,9}. The study by Weatherall et al provide information useful to inform the design and sample size of future trials.

Prehospital NIRS monitoring has been applied almost exclusively in out of hospital cardiac arrest patients during ongoing resuscitation¹⁰, whilst the results of these studies support the feasibility of NIRS monitoring and its value in detecting return of spontaneous circulation¹⁰. Patients with major trauma with and without traumatic brain injury patients may of course differ, especially concerning the possible presence of treatable intracranial lesions that may increase intracranial pressure and hamper cerebral perfusion. Traditionally these patients are identified by a dilated pupil, but in many cases this is already too late¹. A recent study by Ångerman et al investigated the use of NIRS monitoring during induction of anaesthesia performed by the helicopter emergency medical service in the pre-hospital setting prior to transport. Again, NIRS monitoring was feasible with bifrontal signals obtained in 29/31 cases for 95% of a total monitoring time of 1335 minutes. Substantial changes in cerebral oxygenation were observed also in the absence of changes in vital signs and the authors concluded that NIRS monitoring provided useful information beyond standard monitoring. It should be noted that the extreme haemodynamic changes associated with cardiac arrest might be more significant than those occurring during transport of trauma patients, e.g. a similar magnitude of change in cerebral tissue oxygenation from the extreme low of 25-35% could be different compared to an increase from the normal low of 50%.

The even bigger question is of course what the clinician should do with the NIRS value; will it influence patient management? Intuitively one would think that aiming high must be good. However, in post cardiac arrest patients, in the largest study conducted to date, no association was found between mean NIRS values obtained during the first 36 hours in the ICU with either neuron specific enolase, as a biomarker of neurological injury, or outcome¹¹. One other possibility would be to use NIRS to identify the optimal cerebral perfusion setting for each individual patient, but this is likely not possible in the pre-hospital setting. More probable would be the identification of the critical patient with seemingly stable vital functions but nonetheless signs of cerebral ischaemia as shown in the by Ångerman and colleagues¹². The interventions available may include modifying blood oxygen and carbon dioxide levels, improving mean arterial pressure^{8,9,13,14} or administration of agents aimed at rapidly lowering the intracranial pressure¹.

There is plenty of work ahead before NIRS is in routine use in any clinical setting, even more so in the challenging pre-hospital setting. Weatherall and colleagues are providing valuable data paving the way on the immensely difficult path of providing more detailed continuous monitoring in these very complex patients.

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