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INVITED COMMENTARY

Relationship Between Brain Tissue Oxygen and Near-Infrared Spectroscopy in Patients with Nontraumatic Subarachnoid Hemorrhage: Invited Commentary

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In this new study developed by the Hugues de Courson team at Bordeaux University Hospital [1], the interchangeability between brain tissue oxygen ($PbtO_2$) and near-infrared spectroscopy (NIRS) in patients suffering from nontraumatic subarachnoid hemorrhage (SAH) was evaluated for the assessment of cerebral oxygenation. The authors designed this study, despite knowing all the limitations of NIRS. However, they considered it essential to do so, as $PbtO_2$ is an invasive monitoring system (involves the intracranial insertion of a catheter) and is not available worldwide. Unfortunately, their data show no significant correlation between NIRS and $PbtO_2$ values in patients with SAH. NIRS is unable to detect $PbtO_2$ values below 20 mm Hg and decreases in $PbtO_2$ values greater than or equal to 10%. De Courson et al. [1] conclude that the use of $PbtO_2$ cannot be substituted for NIRS in patients with SAH. Although this study does not have a real sample size, it was performed with a very well-done statistical analysis. On the other hand, however, as specified in the limitations, the data were collected manually by the assistance staff on an hourly basis: apparently, this reduces the ability to detect minimal variations in values over time.

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Unfortunately, we now know well from the literature that NIRS, as a method of evaluating regional oxygen saturation, has proved to be very disappointing. In comparative studies performed between healthy patients and patients who died [2] and between common vegetables and healthy subjects, the values are almost comparable. However, NIRS is widely used in the qualitative analysis of agribusiness. Nevertheless, NIRS is used daily in some settings of vascular surgery as guiding parameters (i.e., carotid surgery). In the context of patients with SAH, the occurrence of delay cerebral ischemia (DCI) remains a complication responsible for a high level of poststroke disability. For this reason, monitoring DCI using standard criteria (the appearance of new focal neurologic deficit or a decrease in Glasgow Coma Scale of ≥ 2 for at least 1 h, not ascribable to other diagnoses) is mandatory. Intensivists know that the best way to monitor DCI is by neurological examination of the awake patient. On the other hand, for patients in whom intracranial pressure is at the upper limits or difficulties in ventilatory management coexist and it is necessary to keep the patient sedated, a nonclinical monitoring system is needed. From the literature, we know that no neuromonitoring is sufficiently reliable, and there is no evidence of the superiority of a single parameter. For this reason, it is always necessary to continuously use multiple evaluation systems (multimodal neuromonitoring): $PbtO_2$, transcranial Doppler, brain perfusion computed tomography, continuous electroencephalogram, microdialysis, and its derived parameters. It is also well known that not all centers worldwide have all these invasive and expensive monitoring systems available. Finally, another important limitation of NIRS

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and $PbtO_2$ is that they serve as an assessment of cerebral oxygenation, but they are exclusively regional and only provide information on the area explored.

Readers must grasp some clear messages from this honorable article: NIRS is not a good system for assessing brain oxygenation in patients with SAH at risk of DCI (there are too many confounding factors). When available, it is best to use $PbtO_2$. Nevertheless, it must always be considered that $PbtO_2$ requires a long period of settling (up to 12 h [1]) to provide reliable data.

Ultimately, from a clinical point of view, nothing is more reliable than the neurological examination of a patient with SAH to diagnose DCI, so as much as possible, it is always better to keep the patient awake. In case this is not possible, $PbtO_2$ is an important element in the context of continuous multimodal neuromonitoring. Any changes in regional cerebral oxygenation must be faced with the hemodynamic perturbation while remaining attentive to possible systemic complications [3].

Abbreviations
$PbtO_2$: Brain tissue oxygen; NIRS: Near-infrared spectroscopy; SAH: Subarachnoid hemorrhage; rSO_2: Regional oxygen saturation; DCI: Delay cerebral ischemia.

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RA contributed to the manuscript conception and design. Author read and approved the final manuscript.

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Code Availability
A specific custom code will be given by the corresponding author, RA, upon reasonable request.

Conflict of interest
The author declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethics Approval
The study was conducted in accordance with the declaration of Helsinki and the principles of good clinical practice.

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