Partial pressure of brain tissue oxygen

Monitoring of cerebral oxygenation is considered to be of great importance in minimizing secondary hypoxic and ischemic brain damage following severe head injury. Although the threshold for cerebral hypoxia in Jugular Venous Oxygen Saturation (measurement of O2 saturation in the jugular vein (SjvO2)) is generally accepted to be 50% oxygen saturation, a comparable value in Brain tissue oxygen monitoring (ptiO2), a new method for direct assessment of PO2 in the cerebral white matter, has not yet been established.

Te purpose of a study was to compare brain PtiO2 with SjvO2 in severely head injured patients during phases of reduced cerebral perfusion pressure (CPP) to define a threshold in brain PtiO2 monitoring. In addition, the safety and data quality of both SjvO2 and brain PtiO2 monitoring were studied. In 15 patients with severe head injuries, SjvO2 and brain PtiO2 were monitored simultaneously. For brain PtiO2 monitoring a polarographic microcatheter was inserted in the frontal cerebral white matter, whereas for SjvO2 measurements were obtained by using a fiberoptic catheter placed in the jugular bulb. Intracranial pressure was monitored by means of an intraparenchymal catheter. Mean arterial blood pressure, CPP, end-tidal CO2, and arterial oxygen saturation (pulse oximetry) were continuously recorded. All data were simultaneously stored and analyzed using a multimodal computer system. For specific analysis, phases of marked deterioration in systemic blood pressure and consecutive reductions in CPP were investigated. There were no complications that could be attributed to the PtiO2 catheters, that is, no intracranial bleeding or infection. The “time of good data quality” was 95% in brain PtiO2 compared to 43% in SjvO2; PtiO2 monitoring could be performed twice as long as SjvO2 monitoring. During marked decreases in CPP, SjvO2 and brain PtiO2 correlated closely. A significant second-order regression curve of SjvO2 versus brain PtiO2 ($p < 0.01$) was plotted. At a threshold of 50% in SjvO2, brain PtiO2 was found to be within the range of 3 to 12 mm Hg, with a regression curve “best fit” value of 8.5 mm Hg. There was a close correlation between CPP and oxygenation parameters (PtiO2 and SjvO2) when CPP fell below a breakpoint of 60 mm Hg, suggesting intact cerebral autoregulation in most patients. This study demonstrates that monitoring brain PtiO2 is a safe, reliable, and sensitive diagnostic method to follow cerebral oxygenation. In comparison to SjvO2, PtiO2 is more suitable for long-term monitoring. It can be used to minimize episodes of secondary cerebral maloxygenation after severe head injury and may, hopefully, improve the outcome in severely head injured patients [1)].

The oxygen sensor placed in the white matter of the brain can detect the regional pbtO2. The normal baseline PbtO2 values range from 25 to 35 mm Hg. The death rate increases with time at or below a PbtO2 of 15 mmHg or with the occurrence of any PbtO2values at or below 6 mmHg. Studies have shown that when CPP is less than 60 mm Hg, PbtO2 decreases. Yet, when CPP is greater than 60 mm Hg, however, the effect on PbtO2 is minimal. Recent studies showed that the mortality rate in severe TBI patients treated with conventional ICP/CPP was significantly higher than that of those treated under the PbtO2-directed protocol. Moreover, the PbtO2-directed protocol produced better 6-month clinical outcomes than standard ICP/CPP-directed therapy [2)].

Studies investigating multimodal cerebral monitoring including partial brain tissue oxygen monitoring (ptiO2) in neuro-intensive care patients during physiotherapy are completely lacking in the literature.

Roth et al., performed a post hoc analysis of prospectively collected data of patients on multimodal cerebral monitoring by intracranial pressure (ICP) and cerebral perfusion pressure (CPP) measurement as well as ptiO2. Patients with severe brain diseases were treated with passive range of motion (PROM).

They recorded ICP, CPP, and ptiO2 continuously every minute at baseline (15 minutes), during treatment (26 minutes), and 15 minutes after treatment with PROM. Results Overall, 25 treatment units with PROM in 10 patients with combined ICP/CPP and ptiO2 monitoring were evaluated. Median ICP, CPP, and ptiO2 at baseline were 12 ± 6.1 mm Hg, 86 ± 17.1 mm Hg, and 27 ± 14.3 mm Hg, respectively. Values for ICP, CPP, and ptiO2 did not change significantly when comparing mean values before, during, and after therapy.

Based on ptiO2 measurements, thisr data provide new information about the feasibility and safety of physiotherapy in patients with severe brain diseases [3].

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Kiening KL, Unterberg AW, Bardt TF, Schneider GH, Lanksch WR. Monitoring of cerebral oxygenation in patients with severe head injuries: brain tissue PO2 versus jugular vein oxygen saturation. J Neurosurg. 1996 Nov;85(5):751-7. PubMed PMID: 8893710.
2)
http://www.internationalbrain.org/articles/application-of-brain-tissue-oxygen-monitoring-in-traumatic-brain-injury/
3)
Roth C, Stitz H, Kleffmann J, Kaestner S, Deinsberger W, Ferbert A, Gehling M. Early Physiotherapy by Passive Range of Motion Does Not Affect Partial Brain Tissue Oxygenation in Neurocritical Care Patients. J Neurol Surg A Cent Eur Neurosurg. 2016 Sep 27. [Epub ahead of print] PubMed PMID: 27673345.