Postoperative transcutaneous carbon dioxide monitoring in neurosurgery

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Postoperative monitoring in critical care patients has become a widening field over the past few decades. Improvements in outcome can be related to advances in this field as well as in intraoperative management and preoperative assessment.

Monitoring of respiratory status has become routine and, in adult patients, has largely involved intermittent analysis of arterial blood for partial pressures of O_2 and CO_2 (pO_2(a) and pCO_2(a), respectively) and/or continuous pulse oximetry and end-tidal CO_2 measurement.

Difficulties in continuous monitoring of CO_2 arise in patients who are not intubated and mechanically ventilated when using these standard methods.

This deficiency in postoperative monitoring is particularly relevant in neurosurgical patients who have undergone an intracranial procedure but are not ventilated. Hypercarbia in these patients is associated with cerebral hyperemia and swelling, causing elevation of intracranial pressure.

In addition, neurosurgical patients are at particular risk of hypercarbia due to a number of factors which include hypoventilation due to depressed level of consciousness or pharmacological agents and seizures.

A cycle of worsening hypercarbia with worsening cerebral swelling and further depression of the level of consciousness with worsening hypoventilation and hypercarbia may occur. Standard forms of monitoring may not detect hypercarbia in spontaneously breathing postoperative neurosurgical patients.

In particular, intermittent arterial blood measurement of pO_2(a) and pCO_2(a) may not detect episodic hypercarbia and pulse oximetry gives information only on oxygenation.

Due to the routine use of supplemental oxygen in most postoperative neurosurgical patients, pulse oximetry may be normal despite significant hypercarbia and may not become abnormal until the patient is severely compromised [1].

It is in this setting that transcutaneous CO_2 (tcpCO_2) monitoring is useful. tcpCO_2 is routine in neonatal monitoring practice [2, 3] but there have been reports that it is not appropriate for adult monitoring [4, 5].

Adult skin is thicker and skin blood flow less consistent than in neonates which can make tcpCO_2 measurements more difficult and less accurate [6] particularly in hemodynamically unstable patients.

However, it has been used successfully in adults in sleep studies [7], apnoea testing in brain death [8] and respiratory research [9]. It can also be used to measure local tissue perfusion in skin grafts, amputations and ischemia [10]. It has the advantage of being noninvasive, providing continuous near real-time data and being relatively simple to use.

There have now been a number of studies showing good correlation between tcpCO_2 and pCO_2(a) [1, 8, 9, 11, 12]. There is a lag time of a few minutes if the pCO_2(a) changes rapidly [9, 11] and for this reason tcpCO2 monitoring is probably not appropriate for unstable patients.

It is however most useful for trend monitoring in more stable patients.

With the above factors in mind, tcpCO_2 monitoring in spontaneously breathing patients who had undergone an intracranial procedure was specifically investigated [1].

Sixty-four patients were studied, 39 % of whom developed hypercarbia in the first 36 postoperative hours (30 % moderate, 46-59 mmHg and 9 % severe, 60 mmHg or greater).

Severe hypercarbia was associated with pre- and postoperative seizures, depressed level of consciousness and major procedures. There was a higher rate of reintuba-tion and ventilation in the postoperative period in severely hypercarbic patients.

tcpCO_2 readings were correlated with pCO_2(a) and were found to be sufficiently accurate for this form of monitoring ($R^2 = 0.77$).

No episodes of severe hypercarbia were missed, however mild episodes of hypercarbia (46-50 mmHg) may be underestimated due to the limits of accuracy of the method. Complications included thermal injury to the skin at the site of the heated probe (two patients).

This was avoided by changing of the site of monitoring every 4 hours which makes monitoring relatively labour intensive but not prohibitive.

This study demonstrates that in routine neurosurgical practice, tcpCO_2 monitoring is a valuable technique which may impact management decisions in this group of patients. It allows continuous and reliable monitoring in patients who are at risk of postoperative hypercarbia [1].

References

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