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Arterial to end-tidal carbon dioxide difference in neurosurgical patients undergoing craniotomy: a review of practice

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little incentive to ensure the quality of data they collect or even to comply with reporting requirements.14

Accurate record keeping also generates data that serves research purposes, not to speak of improved planning and management of hospitals and higher quality of services offered. Efforts to improve record keeping hold the promise of a low-cost, low-technology way to establish evidence-based approaches to safer motherhood and family health.

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Original Article

Arterial to End-Tidal Carbon Dioxide Difference in Neurosurgical Patients undergoing Craniotomy: A Review of Practice
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Abstract

Objective: To see if PETCO₂ reflects PaCO₂ with acceptable accuracy.
Methods: In this audit the anaesthetic chart of fifty consecutive patients, age 12 years and above undergoing craniotomy for intracranial pathology, were reviewed.
Results: The difference between end tidal carbon dioxide (ETCO₂) value corresponding to the time of taking the arterial sample and the PaCO₂ was calculated. The mean end tidal CO₂ was 29.3± 2.8 and the mean PaCO₂ was 32.63± 4.5. The mean difference between the two values was calculated as 4.09 ± 3.0. The regression coefficient was 0.496, which showed a moderate association. A wide variability was observed in the results.
Conclusion: Based on our results we recommend that arterial samples should be taken to determine PaCO₂ in neurosurgical patients where maintenance of cerebral blood flow is crucial e.g. cerebral aneurysm surgery (JPMA 57:446:2007).

Introduction

Both PaCO₂ and PETCO₂ are indicators of ventilatory adequacy. It is important to know the PaCO₂ in neuroanaesthesia because of its effect on cerebral blood flow. PETCO₂ has been used as a non-invasive estimate of PaCO₂.1 The usual reported difference between PaCO₂ and PETCO₂ in healthy awake patients is 3.6 to 4.6 mm of Hg2 but a significant variability has been observed in mechanically ventilated neurosurgical ICU patients3 and in patients undergoing craniotomy in different positions.4 There has also been some controversy in recent anaesthetic literature whether end tidal CO₂ (PETCO₂) is an accurate reflection of PaCO₂.3,5

This audit was undertaken to review our routine practice of obtaining PaCO₂ during craniotomy procedures and comparing it with the PETCO₂ at the same time. The objective was to see whether PETCO₂ reflected the PaCO₂ with acceptable accuracy.

Methods

Since the last three years our routine practice in
neuroanaesthesia is to take an arterial blood sample from the arterial line one hour after start of surgery in patients undergoing craniotomy and to note the end tidal carbon dioxide concentration simultaneously. The readings for ETCO₂ are routinely noted on the patient perioperative charts.

In craniotomy patients the ETCO₂ value corresponding to the time of taking the arterial sample is specifically noted on our anaesthetic chart. A file note is also made on ventilatory and haemodynamic parameters at the time of obtaining the sample. The PETCO₂ is taken as the maximal terminal value at end expiration. The charts of the last 50 consecutive patient's age 12 years and above, undergoing craniotomy were reviewed to look for the difference between the two values and to see whether the PETCO₂ value could be substituted for PaCO₂. The difference between the two value P (a-ET) CO₂ was calculated manually for each sample. The other values routinely noted at the time of sampling were heart rate, systolic and mean arterial pressure (SAP, MAP), respiratory rate, tidal volume and inspired oxygen. These patients were undergoing craniotomy for different pathologies.

The institutional ethical committee was consulted and no permission was required for this review of practice.

All these patients had undergone craniotomy in supine position and had no significant lung disease. The patient's lungs were ventilated on Aestiva/5 machine ventilator. Volume controlled ventilation was used and the initial ventilatory setting was to achieve a PETCO₂ of 30-32mm of Hg. Carbon dioxide sampling was done on a side stream sample with the Datex AS/3 monitors. Arterial blood gas samples were taken from the radial artery catheter, which is standard monitoring in a craniotomy at our institution. The sample was sent to the laboratory immediately and was analyzed on NOVA stat profile Ultra (Nova Biomedical International, USA). These results were not corrected for patient's temperature.

Values were entered on the SPSS 13.0 statistical program. Data is presented as mean SD and range of values. Confidence intervals for mean difference between ETCO₂ and PaCO₂ was also calculated. Regression analysis between PaCO₂ and PETCO₂ and its standard error was also calculated.

Results

All patients underwent craniotomy in supine position. The mean age of the patients was 36.05 ± 18.0 years. The median age was 33.5 years. Age range was 12-71 years. 95 CI were 30.2 to 41.8. The mean weight was 62.6 ± 17.0 kgs.

There were 30 males and 20 females. The mean ETCO₂ was 29.30 ± 2.8 (range 23-40 mm of Hg). The mean PaCO₂ was 32.63 ± 4.5 mm of Hg (range 16.8 - 42.5). The mean difference between ETCO₂ and PaCO₂ was 4.09 ± 3.08 with 95% CI = 3.21-4.97 (range 2.7 to 15.2). The regression coefficient was calculated as: 0.496, SE = 3.96. The regression analysis between PaCO₂ and ETCO₂ is shown in Figure 1.

The values differed by less than 6 mm of Hg in 41 patients (82%). The difference was more than 6 mm of Hg in nine (18%) patients. In two patients (4%) a negative correlation was observed.

Discussion

Capnometry is the measurement of the concentration or partial pressure of carbon dioxide at the patient's airway during the entire ventilatory cycle. It provides a numerical measurement of inspired and end tidal CO₂. The end-tidal CO₂ or PETCO₂ closely approximates the arterial PCO₂ in normal lungs. The two common causes of more than normal difference are ventilation/perfusion mismatch and poor sampling of gas at patients end. End tidal CO₂ measurement is currently the standard of care where general anaesthesia is administered.

The average P (a-ET) CO₂ gradient was determined as 4-6 mm of Hg in patients with normal lungs by Nunn et al. Other investigators have come up with similar figures: Takki et al, 3-5 mm of Hg, Weingner 4±2 mm of Hg, and Ashrog, 5 ±2 mm of Hg. No correlation was found with age and systolic arterial pressure. In respiratory failure patients, the average P (a-ET) CO₂ gradient was found to be 18 mm of Hg.

Several other factors have been shown to affect this relationship e.g. positioning, site of measurement i.e.
The measurement of arterial PaCO2 is of special importance in neuroanaesthesia because of its effect on cerebral circulation. In order to have a noninvasive measure of PaCO2 several authors have investigated this relationship between PaCO2 and end tidal CO2 in neuroanaesthesia with mixed results. Sharma16 found this mean difference to be 5 ± 2 mm of Hg, but with large individual variations between -14 to 10 ± 19 mm of Hg. Kerr looked at head injured patients and found a mean difference of 6 ± 6 mm of Hg. Russell and Greybell3 found the mean difference to be 7 ± 3 mm of Hg in neurosurgical patients in the operating room and 7 ± 4 mm of Hg in ICU. They found a correlation coefficient of 0.63. Isert4 found this difference to be 4 ± 4 mm of Hg and observed that end tidal CO2 correlated with PaCO2 in 82% cases. Excellent correlation was shown by Mackersie et al who looked at data of 36 patients with known or suspected severe head injury. They found a correlation coefficient of 0.63. Isert4 found this difference to be 4 ± 4 mm of Hg and observed that end tidal CO2 correlated with PaCO2 in 82% cases. Excellent correlation was shown by Mackersie et al who looked at data of 36 patients with known or suspected severe head injury.5 Grenier et al12 showed a poor correlation and recommended arterial blood gas in addition to capnography. Ferber et al18 also showed poor correlation in patients undergoing craniotomy for head injury.

In our data the mean difference was 4.09 (+ 3.08) CI. These results are very similar to those shown by Isert et al.4 We also found a wide variability with the lowest value as -2.7 and the highest as +15.2. We found an r value (regression coefficient of 0.496). This only shows a moderate association and not a strong one.19

Eighty two percent of our values differed by less than 6 mm of Hg. Negative correlation was observed in only 2 patients (4%). Negative values have also been reported by other investigators in neuroanaesthesia3,4, and slow emptying of alveoli with long time constant has been hypothesized as the mechanism12 but this concept has been challenged. A higher incidence of negative values have been reported in children, in laparoscopic surgery or after cardiac surgery,2,20,21 and in pregnancy.14 Negative correlation was seen in 20% of patients undergoing sub-arachoid haemorrhage surgery.18 Both our patients in whom negative values were reported had a history of hypertension but did not have any respiratory disease. The haemodynamic parameters were stable at the time of sampling.

In summary we observed that a relationship between PaCO2 and end tidal CO2 was predictable in only 49% of patients. A wide variability was seen in the results. Hence based on this audit we would recommend that arterial blood samples should be taken to determine PaCO2 in neurosurgical patients undergoing craniotomy where maintenance of cerebral blood flow is crucial e.g. during cerebral aneurysm surgery or patients with large intracranial tumours. In neurosurgical patients undergoing surgery for small superficial tumours with minimal disruption of cerebral blood flow and intracranial pressure, the cost benefit analysis may not favour arterial sampling.

References


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