Interference of volatile anaesthetics with infrared analysis of carbon dioxide and nitrous oxide tested in the Dräger Cicero EM using sevoflurane

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Summary

In theory, setting an infrared multi-gas analyser to measure a volatile anaesthetic different from that in the sampled gas mixture may cause interference with carbon dioxide and nitrous oxide readings. The theory was investigated during evaluation of the Dräger Cicero EM anaesthetic workstation for the Medical Devices Agency. Interference occurred as predicted, and was most pronounced when the vapour analyser of the Cicero EM was deliberately and erroneously set to measure isoflurane, but with sevoflurane present in the gas mixture. With 6% sevoflurane in the gas mixture, the carbon dioxide reading decreased from 5% to 3.6%, and the nitrous oxide reading increased from 0% to 8% although, as the apparent isoflurane reading was 9%, the Cicero EM would alert the operator to the problem. However, operators are encouraged to ensure that, when using gas analysers such as that incorporated into the Cicero EM, the analyser is set to measure the correct volatile anaesthetic (the Cicero EM does this automatically when a Vapor vaporizer is attached) and the breathing system does not contain any other volatile anaesthetic agents. (Br. J. Anaesth. 1996; 76: 737–739)

Key words


Infrared absorption is a common method of gas analysis for measuring the concentrations of carbon dioxide, nitrous oxide and volatile anaesthetic agents in gas mixtures during anaesthesia. This type of analyser uses different wavelengths of infrared light to determine the concentrations of carbon dioxide, nitrous oxide and volatile anaesthetic; the same wavelength is used for all current volatile anaesthetics, but different sensitivities are set for each agent. Typically, the highest sensitivity is set for halothane and the lowest for sevoflurane. This method of analysis implies that the presence of a volatile anaesthetic different from that set to be measured causes an error in the volatile anaesthetic reading. For example, 1% isoflurane causes an apparent halothane reading of approximately 6% when the analyser is set to measure halothane [1].

Volatile anaesthetics also absorb infrared radiation at the wavelengths used for measurement of carbon dioxide and nitrous oxide. This is corrected by subtracting amounts from the carbon dioxide and nitrous oxide signals appropriate to the volatile anaesthetic being measured and its measured concentration. Therefore, provided the analyser is set to measure the correct anaesthetic, or the analyser detects the particular volatile anaesthetic automatically, the analyser can compensate for this effect. However, if the analyser is set to measure a volatile anaesthetic different from that present in the gas mixture, the wrong corrections are made and the carbon dioxide and nitrous oxide readings are in error.

An opportunity to test this theory occurred during evaluation of the Dräger Cicero EM anaesthetic workstation for the Medical Devices Agency. This anaesthetic workstation incorporates the ANDROS 4610 gas analyser, which is also used in the North American Dräger Narkomed 4 and Vitalert 3000 monitor, and the Drägerwerk PM 8050 monitor. Information provided by the manufacturer stated that the analyser software compensates for the cross-sensitivity of carbon dioxide, nitrous oxide and volatile anaesthetic, so that the displayed concentrations of these gases and vapours are accurate. However, it was found that if the ANDROS 4610 was set deliberately to measure a volatile anaesthetic different from that in the gas mixture being sampled, interference with the carbon dioxide and nitrous oxide readings occurred as predicted. The interference was most pronounced with sevoflurane present in the gas mixture and with the analyser set to measure isoflurane. The extent of the interference was investigated.

Methods and results

Carrier gas (4.95% carbon dioxide/balance nitrogen) (BOC Special Gases) was set at a flow of 2 litre min⁻¹ using a RT-200 calibration analyser (Timeter Corp) and was passed through a vaporizer (Sevotec 3, Ohmeda) to add various concentrations of sevoflurane to the gas mixture. A turbine vane transducer cartridge from a 5410 volume monitor (Ohmeda), placed in the gas pathway, was used to ensure that the carrier gas and sevoflurane were mixed thoroughly. The resulting gas mixture was sampled from

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The concentration of carbon dioxide in the gas mixture was also checked with the refractometer. The concentration of carbon dioxide and nitrogen remained the same, and correcting for temperature and pressure at 101.3 kPa [3] and 282.12 for nitrogen (at 15 °C and 101.3 kPa [4]), assuming that the relative concentration of the volatile anaesthetic in use is set to measure sevoflurane, then the nitrous oxide reading increases from 0 to 6 %. The Cicero EM detects which vaporizer has been fitted using a coding on the rear of Dräger Vapor 19.n vaporizers and automatically selects the appropriate sensitivity on the gas analyser. Therefore, in normal clinical practice, it would require a deliberate action by the anaesthetist to set the analyser to measure a volatile anaesthetic different from that of the vaporizer on the Cicero EM workstation. Even then, an advisory message is displayed and, if the vaporizer is changed, the setting of the analyser is automatically changed appropriately. Therefore, in the Cicero EM, inappropriate setting of the gas analyser is extremely unlikely. However, when that analyser (or any other analyser working on the same principle) is used in isolation (as was effectively the case in these experiments), the correct setting of the anaesthetic to be measured is dependent on the operator.

In addition, the volatile anaesthetic in use is absorbed into the walls of the breathing system [5,6]. During subsequent use with a different anaesthetic, the anaesthetic used previously desorbs from the breathing system and is present in the gas sampled by the analyser, causing interference. Using a low-flow system exacerbates this effect.

Whatever the circumstances—whether the analyser is set to measure the wrong volatile anaesthetic or the sample from the breathing system contains an additional, “foreign”, agent—the displayed concentration of the volatile is the concentration used to determine the interference effect on the nitrous oxide reading. Again, if the analyser is set correctly to measure sevoflurane, then the nitrous oxide reading is accurate. However, if the analyser is set to measure isoflurane, and 5 % sevoflurane is in the gas mixture (as specified in ISO/DIS 11196), the nitrous oxide reading increases from 0 to 6 %. The International Standard for anaesthetic gas monitors (ISO/DIS 11196) specifies gas mixtures to be used to determine the interference effect on the nitrous oxide reading. However, if the analyser is set to measure isoflurane, and 5 % sevoflurane is in the gas mixture, then carbon dioxide reading decreases with this gas mixture from 5 % to 3.6 %. Conversely, if isoflurane is present in the gas mixture, and the analyser is set to measure sevoflurane, the carbon dioxide reading increases as the sevoflurane concentration increases. The draft International Standard for anaesthetic gas monitors (ISO/DIS 11196) specifies gas mixtures to be used to determine the interference effect on the nitrous oxide reading. Therefore, the analyser is set to measure isoflurane, and 5 % sevoflurane is in the gas mixture (as specified in ISO/DIS 11196), the nitrous oxide reading increases from 0 to 6 %.

The slope of the change in carbon dioxide reading with increasing sevoflurane concentration was −0.24, and that for nitrous oxide, +1.27.

**Comment**

The International Standard for capnometers (ISO 9918:1993) specifies gas mixtures to be used to determine the interference effect of gases and vapours on the carbon dioxide reading. One such gas mixture specified is 6 % sevoflurane in 5 % carbon dioxide, balance nitrogen. If the ANDROS analyser in the Cicero EM is set correctly to measure sevoflurane in the gas mixture, then carbon dioxide readings are displayed which are within the tolerance specified in ISO 9918:1993. However, if the analyser is set to measure isoflurane, the carbon dioxide reading decreases with this gas mixture from 5 % to 3.6 %. Conversely, if isoflurane is present in the gas mixture, the carbon dioxide reading increases as the sevoflurane concentration increases. The draft International Standard for anaesthetic gas monitors (ISO/DIS 11196) specifies gas mixtures to be used to determine the interference effect on the nitrous oxide reading. Again, if the analyser is set correctly to measure sevoflurane, then the nitrous oxide reading is accurate. However, if the analyser is set to measure isoflurane, and 5 % sevoflurane is in the gas mixture (as specified in ISO/DIS 11196), the nitrous oxide reading increases from 0 to 6 %.

A common sampling point, both by the ANDROS analyser on a Cicero EM anaesthetic workstation (Dräger, Germany) and by an interference refractometer on loan from the National Physical Laboratory [2]. The gas mixture sampled was therefore independent of the breathing system of the Cicero EM. At each vaporizer setting, the analyser was set to measure sevoflurane and the carbon dioxide, nitrous oxide and volatile anaesthetic readings were noted; the analyser was then set to measure isoflurane and the readings repeated. The readings were also logged automatically onto a computer (Apple Macintosh LC475 running Kermit communication software) via the RS232 serial output on the Cicero EM. Changes in the carbon dioxide and nitrous oxide readings were taken to be the difference between the pairs of readings obtained at each vaporizer setting. The actual concentration of sevoflurane in the gas mixture was determined from the refractometer using refractive powers of 1428.6 for sevoflurane, 413.56 for carbon dioxide (at 22 °C and 101.3 kPa [3]) and 282.12 for nitrogen (at 15 °C and 101.3 kPa [4]), assuming that the relative concentrations of carbon dioxide and nitrogen remained the same, and correcting for temperature and pressure [3]. The concentration of carbon dioxide in the carrier gas was also checked with the refractometer.

The carbon dioxide and nitrous oxide readings changed linearly with sevoflurane concentration (fig. 1).
or nitrous oxide. Nevertheless, it is important to be aware that the carbon dioxide and nitrous oxide readings are also in error.

The Dräger Cicero EM incorporates a sophisticated and generally accurate gas analyser. However, when using this, or a similar gas analyser, operators should check that the analyser has been set to measure the correct anaesthetic, and should be vigilant that the breathing system does not contain a mixture of volatile anaesthetics. Failure to do so could cause interference with the carbon dioxide and nitrous oxide readings and also give a false reading for the volatile anaesthetic.

References