Low-flow anaesthesia and carbon monoxide in paediatric patients

Editor—We read with interest the paper by Nasr and colleagues regarding carbon monoxide (CO) rebreathing during low-flow anaesthesia (LFA) in infants and children and an earlier study by the same authors. We would like to call attention to two confounding issues. First, they have stated that an electrochemical sensor was used for measurement of CO in these studies in the range 0–2000 ppm, resolution 1 to 2 ppm (Monoxor III, Bacharach Inc., Anderson, CA, USA). According to the manual for this device, it is designed to detect and display concentrations of CO in ambient air, flue gases, or combustion equipment, and its accuracy is ±5% or ±10 ppm, whichever is greater. The authors have reported that inspired concentrations of CO were mean 2.0 ppm (0–14 ppm) during LFA and 2.6 ppm (0–18 ppm) in the earlier study. It is clear that these values are too small to be placed in the limits of measurement error and questionable. Secondly, there is a disagreement between the results of the two papers. The authors reported that LFA increased exhaled and inspired CO and increased COHb in children <2 yr, in contrast to their earlier study where LFA increased CO and COHb in children >2 yr. This important difference has not been explained. We suggest that the authors had not used an appropriate device for the measurement of CO and the results of the studies are contradictory and unreliable.

Declaration of interest
None declared.

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Reply from the authors
Editor—We appreciate the interest in and critique of our work1 provided by Drs Tomatir and Bozkurt-Sutas. In their comments, the authors state that the carbon monoxide (CO) values measured in both of our studies were within the limits of measurement error of the device used, making them questionable. They go on to state that we did not use an appropriate measurement device and therefore our results are unreliable. Although gas chromatography is considered the gold standard for measuring CO, its limitations make it less than ideal for use in certain clinical investigations. The specific electrochemical sensor technology we utilized for both of our studies has been validated to detect CO in the presence of volatile anaesthetic agents within the breathing circuit.2 Although the authors are correct that the resolution of the electrochemical sensor is 1 ppm with an accuracy of ±5% or 10 ppm, they have made some generalizations and have overlooked key aspects to both studies.

First, although the mean value of inspired CO in our first study was 2.6 ppm, the range was from 0 to 18 ppm.3 In that study, there were many detected values above 10 ppm. In our article in BJA,1 ranges of detected CO were from 0 to 24 ppm. Our critics should realize that accuracy is a measurement’s degree of absolute correctness while resolution is the smallest amount detectable. One could argue that 2 ppm CO may not carry much significance as a specific quantity, per se; however, the fact that CO was present and detectable at even the smallest concentrations within the breathing circuit carries great importance. The limitations of detecting small amounts of CO within the circuit were obvious to us which is precisely why we assessed for changes in COHb as an indicator of CO exposure.

As anaesthetists, we recognize and adapt to the inherent imprecision with our monitors and devices every day. For example, commonly used non-invasive capnography has a resolution of 0.13 kPa with an accuracy of ±5% for carbon dioxide levels between 5.4 and 9.3 kPa and ±8% for levels >9.3 kPa.4 In addition, we know that end-tidal carbon dioxide levels often do not correlate exactly with PaCO2 values due to dead space, etc. However, we use end-tidal values to dictate management and follow the trends of these measurements over time. In our article, it was the slope in the change in CO over time (not actual CO values) that was critical to understanding the relationship to FGF:Ve and evidence of CO re-breathing.1

The authors’ review of our work shows flaws in their interpretation and conclusions. Our two studies differed dramatically in study design and approach. In the first study, we fixed FGF at 1.5 litre min−1 and permitted each child’s minute ventilation to vary. Thus, in the smallest children, FGF:Ve exceeded 1 and no re-breathing occurred.5 As a consequence, inspired CO was undetectable and these younger children demonstrated a decrease in COHb.

doi:10.1093/bja/aer463

doi:10.1093/bja/aer470