Effects of nitrous oxide on end-tidal carbon dioxide measurements in spontaneously breathing patients under general anesthesia

Dear Editor,

It is common practice to administer nitrous oxide (N_2O) along with inhalational anesthetic agents to take advantage of its additive effect on minimal alveolar concentration levels. Measurement of the end-tidal carbon dioxide ($EtCO_2$) concentrations is a component of the American Society of Anesthesiologists Standards for Basic Intra-Operative Monitoring and has become standard of care for patients undergoing general anesthesia. We write to discuss two mechanisms where the use of N_2O can erroneously alter the $EtCO_2$ levels.

A 26-year-old male, with a left radial nerve injury, was posted for tendon transplantation. He underwent tendon transplantation under general anesthesia and spontaneously breathed with a supraglottic airway device (I-gel; size 4). Adequate depth of anesthesia and analgesia was maintained to prevent tachypnoea, sighing, intra-operative awareness, and movement. Ten minutes into the surgery, a gradual rise in the $EtCO_2$ level was noted in spite of constant ventilatory parameters. The intra-operative parameter measures are given in **Table 1**.

This rise in the measured level of $EtCO_2$ may be explained by an insufficiently narrow infrared filter used for measurement of $EtCO_2$ levels, or by a collision broadening phenomenon.

(i) Insufficiently narrow infrared filter: The standard capnograph works on the principle that carbon dioxide absorbs infrared radiation. When infrared light of a spectrum is passed through a gas mixture containing CO_2 , some of the infrared light is absorbed, and less amount of light reaches the sensor at the opposite end. However, the presence of N_2O in the gas mixture may interfere with this because of the similar infrared absorption spectra of both gases (4.5 μM for N_2O and 4.3 μM for CO_2). Therefore, the use of an insufficiently narrow infrared filter sensor of the monitor may lead to an erroneously high $EtCO_2$ reading, and the same may be corrected by using an infrared filter sensor with a narrower absorption range.

(ii) Collision broadening phenomenon¹: This refers to the phenomenon of the spectral absorption peak of a gas being broadened owing to the collision or proximity of molecules of another gas. Therefore, due to this phenomenon, the presence of co-administered N_2O in the fresh gas flow would cause a broadening of the spectral gas absorption peak of CO_2 . This broadening of the spectral absorption peak causes a falsely high $EtCO_2$ reading. While this is a common phenomenon, most monitors have an electronic compensation to account for this effect wherein the monitor is calibrated with a gas mixture that contains the same background gas concentration as that to be analyzed. Additionally, various correction factors have also been studied wherein the actual $EtCO_2$ can be derived from the measured $EtCO_2$, with the correction factors differing according to the amount of N_2O present in the fresh gas flow. One such factor is

as follows (**Table 2**).^{2,3}

We reported this case as an informal survey of anesthesiologists with a low awareness of the existence of this phenomenon, which has clinical importance as it can lead to inappropriate hyperventilation of the patient.

Table 2: Actual end-tidal carbon dioxide corrected according to the amount of N_2O present in the fresh gas flow

N_2O present in fresh gas flow	Corrected reading
70%	Observed $pCO_2 \times 0.9$
50%	Observed $pCO_2 \times 0.94$

Note: N_2O : Nitrous oxide; pCO_2 : partial pressure of carbon dioxide.

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Table 1: Measurement of intraoperative parameters

Time after surgery start (min)	O_2 (L/min)	N_2O (L/min)	$EtCO_2$ (mmHg)	Sevo (v/v)	MAC (%)	RR (times/min)	Vt (mL)	MV (L/min)	HR (beats/min)	FiO_2 (%)
0	8	—	48	2	1.1	20	380	7.62	84	96
5	8	5	53	2	1.2	19	355	7.1	85	64
10	8	5	56	2	1.2	18	380	7.64	84	62
15	8	5	55	2	1.0	17	430	7.29	82	62
20	8	—	47	2	0.8	21	410	8.26	87	95

Note: $EtCO_2$: End-tidal carbon dioxide concentrations; FiO_2 : fraction of inspiratory oxygen; HR: heart rate; MAC: minimal alveolar concentration; MV: minute volume; N_2O : nitrous oxide; O_2 : oxygen; RR: respiratory rate; Sevo: sevoflurane; Vt: tidal volume.