



## Postoperative apnea and hypercapnia due to intentional breath holding in a freediver

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### To the Editor,

We describe a case of intentional breath holding during emergence from general anesthesia which led to a failure to extubate the patient's trachea upon emergence. We postulate that the intentional breath holding was related to the patient's training in the sport of freediving. The patient provided written consent for publication.

A 42-yr-old male with a body mass index of  $25 \text{ kg}\cdot\text{m}^{-2}$  was booked for open reduction and internal fixation of an olecranon fracture. His only comorbidity was mild well-controlled asthma. He was a non-smoker, appropriately fasted, and otherwise healthy. Examination of the patient's airway revealed mild micrognathia with a Mallampati 3 view, which was assessed as a potentially difficult intubation. We elected to secure his airway with a tracheal tube.

Following intravenous induction with fentanyl 150  $\mu\text{g}$ , propofol 200 mg, and rocuronium 50 mg, direct laryngoscopy revealed a Cormack-Lehane grade 2 view and tracheal intubation was uneventful. Anesthesia was maintained with desflurane and the surgery lasted 45 minutes. At emergence, desflurane was discontinued and reversal of neuromuscular blockade was given following an appropriate train-of-four (Table). The patient regained consciousness at an end-tidal (ET) desflurane 0.6%; he followed verbal commands to open and close his eyes and squeeze the anesthesiologist's fingers. On regaining consciousness, however, the patient began to have apneic episodes lasting as long as 60 seconds. Attempts to ventilate his lungs manually and assist the few breaths he was taking were resisted with bucking and coughing.

For approximately five minutes, we failed to effectively ventilate the patient's lungs. During this time, his  $\text{ETCO}_2$  rose to 65 mmHg, and he became obtunded; however, his oxygen saturation did not fall below 93% at any point. Anesthesia was re-induced to gain control of the situation. A bolus dose of propofol 150 mg was administered, and the volatile anesthetic was changed to sevoflurane to rule out any chance of bronchial irritation associated with a volatile agent.

Approximately one minute after recommencing general anesthesia and mechanical ventilation, an arterial blood gas sample was taken which showed an acute respiratory acidosis with no metabolic component. A number of differential diagnoses were discussed and excluded (Table). Emergence agitation was considered but thought unlikely to be the cause of apnea.<sup>1,2</sup> A repeat arterial blood gas sample showed resolution of the respiratory acidosis. Sevoflurane was discontinued, and the patient regained consciousness, obeyed commands, and breathed regularly. The tracheal tube was removed uneventfully.

In the postanesthesia care unit, the patient volunteered that he remembered the initial attempt at extubation. He recollected waking and following instructions but had an impulse to hold his breath. He attributed this impulse to his training in the sport of freediving.

There is a fast expanding repertoire of sport which incorporates the ability to perform prolonged apnea.<sup>3</sup> The implications of these competitive apneic sports on anesthesia should be explored. Freedivers are unique individuals who have "trained" the autonomic nervous system to achieve the goals of their sport.<sup>4</sup> The maximum length of apnea is ten minutes twelve seconds and the greatest depth achieved is 214 m.<sup>5</sup> Freedivers have been shown to have a heightened mammalian dive reflex, increased parasympathetic resting cardiac autonomic tone, and a blunted response to elevated  $\text{CO}_2$  concentrations.<sup>6</sup>

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**Table** Timeline of events and reasons for exclusion of the differential diagnoses of apnea

End of surgery as Time 0	Course of events	Reason of exclusion for causes of apnea
Time 0	<ul style="list-style-type: none"> <li>• Train-of-four = 4 (ulnar nerve)</li> <li>• Reversal given</li> <li>• Desflurane flushed from system</li> </ul>	<ul style="list-style-type: none"> <li>• Appropriate reversal of neuromuscular blockade</li> </ul>
Time 3 min	<ul style="list-style-type: none"> <li>• ET desflurane = 2.4%</li> <li>• Spontaneously breathing with appropriate tidal volumes and rate</li> <li>• No wheezing</li> </ul>	<ul style="list-style-type: none"> <li>• No signs of bronchial irritation, opiate narcosis or inadequate reversal of neuromuscular blockade</li> </ul>
Time 5-9 min	<ul style="list-style-type: none"> <li>• ET desflurane = 0.6%</li> <li>• Awake and following motor commands</li> <li>• Periods of apnea for up to 60 sec</li> <li>• Bite block <i>in situ</i> and tracheal tube patent</li> <li>• Second dose of reversal; sustained tetanus 50 Hz x 5 sec</li> <li>• Naloxone 80 µg</li> </ul>	<ul style="list-style-type: none"> <li>• Volatile anesthesia &lt; 0.1 MAC</li> <li>• Neuromuscular blockade reversed; sustained tetanus</li> <li>• Tracheal tube patent</li> <li>• Opiate narcosis unlikely; naloxone given</li> </ul>
Time 10 min	<ul style="list-style-type: none"> <li>• Patient obtunded with ET<sub>CO<sub>2</sub></sub> 65 mmHg</li> <li>• Anesthesia recommenced with propofol and sevoflurane</li> </ul>	<ul style="list-style-type: none"> <li>• Desflurane exchanged for sevoflurane to reduce possibility of bronchial irritation</li> </ul>
Time 12 min	<ul style="list-style-type: none"> <li>• ABG pH = 7.23, pCO<sub>2</sub> = 59 mmHg, pO<sub>2</sub> = 384 mmHg</li> </ul>	<ul style="list-style-type: none"> <li>• Acute respiratory acidosis, no metabolic component</li> </ul>
Time 20 min	<ul style="list-style-type: none"> <li>• ABG pH = 7.33, pCO<sub>2</sub> = 47 mmHg, pO<sub>2</sub> = 408 mmHg</li> <li>• Chest <i>x-ray</i> normal</li> <li>• Normal chest auscultation</li> <li>• Sevoflurane discontinued</li> </ul>	<ul style="list-style-type: none"> <li>• Normal ABG</li> <li>• Normal chest <i>x-ray</i> and auscultation</li> </ul>
Time 25 min	<ul style="list-style-type: none"> <li>• ET sevoflurane = 0.2 %</li> <li>• Awake, following motor commands, appropriate tidal volumes and respiratory rate</li> <li>• ET<sub>CO<sub>2</sub></sub> 43 mmHg</li> <li>• Trachea extubated</li> </ul>	<ul style="list-style-type: none"> <li>• Patient breathing normally</li> <li>• Normal ET<sub>CO<sub>2</sub></sub> waveform and range</li> </ul>
Time 60 min	<ul style="list-style-type: none"> <li>• Debrief; patient volunteered he was intentionally breath holding</li> </ul>	<ul style="list-style-type: none"> <li>• Intentional breath holding as the most likely diagnosis by exclusion</li> </ul>

ABG = arterial blood gases; ET = end-tidal; ET<sub>CO<sub>2</sub></sub> = end-tidal carbon dioxide; Reversal = Neuromuscular relaxant reversal Glycopyrolate 400 mcg and Neostigmine 2.5 mg

In summary, we report a unique case of intentional breath holding and postulate that this is related to the patient's training in freediving. We consider this an important case to bring to the attention of anesthesiologists who may come across this growing population of patients in the future.

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**Conflicts of interest** None declared.

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