Don't hold your breath: anoxic convulsions from coupled hyperventilation–underwater breath-holding

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Clinical record

We report anoxic convulsions occurring in two medical students competing in a breath-hold dive competition in shallow water. The seizure-like activity occurred during a competition called the "Dolphin Dive", which was part of a university medical school swimming function. The goal set for the competitors was to swim as far as possible underwater in a swimming pool without taking a breath. Three students participated in the event and two students had convulsions. In both cases, the students hyperventilated before the dive.

Student 1

A 27-year-old man, with a past medical history of asthma, had been involved in underwater hockey and spear fishing, and was previously able to underwater breath-hold for 2 minutes while keeping still. During the competition, he swam about 60 metres and spent 40 seconds underwater. After the dive, he stood up in the water, lost consciousness and was witnessed to have multifocal myoclonic jerks lasting about 1 minute. He recalled some jerking of the limbs when asked afterward.

Student 2

A 27-year-old man, with no significant past medical history, had previously swum at national championship level and had worked as a surf lifesaver. He reported swimming about 85 metres for the competition and spending 90 seconds underwater. At the end of his dive, he became unconscious, floated to the surface of the pool and had multifocal myoclonic jerks lasting less than 1 minute. He had no recollection of the convulsive movements.

Many people were observing the race and so the students were rapidly retrieved from the pool; they regained consciousness and did not experience any long-term consequences. ◆

The seizure-like activity that occurred in the two university students was probably convulsions secondary to cerebral hypoxia induced by breath-holding.

Anoxic convulsions result from interruption of the oxygen supply to metabolically active neurones, particularly in the cerebral cortex.[1] They may be regarded as a brainstem-release phenomenon in which primitive movements can occur, particularly multifocal arrhythmic myoclonic jerks.[1,2] They can result from voluntary breath-holding, such as cyanotic breath-holding of early childhood.[1]

Swimmers often hyperventilate before breath-holding to reduce the urge to breathe from hypercapnia. This may result in prolonged breath-holds with consequent hypoxaemia. Loss of consciousness may ensue without forewarning because the respiratory stimulus from hypoxaemia is weak and easily overridden.[3] Vigorous exercise, such as underwater swimming, may exacerbate hypoxia by increasing oxygen consumption. These factors are likely to result in syncope occurring late in the dive, as in our two cases.

Hyperventilation-induced hypocapnia is known to constrict cerebral vasculature and may contribute to syncope.[2] In addition, the Valsalva manoeuvre can cause syncope during the early stages of a breath-hold dive,[4] probably by reducing cerebral blood perfusion further as a result of decreased cardiac output from reduced thoracic venous return. This may be a cause of early syncope before hypoxia and hypercapnia have occurred, but the Valsalva effects may still be operative late in the dive. When Student 1 stood up at the end of his dive, the change in posture would have impaired venous return even more, and may have triggered the anoxic convulsions.

Breath-hold practitioners are often skilled male swimmers who are not closely watched by lifeguards. Loss of consciousness underwater can lead to drowning. A report of 58 cases of syncope during underwater swimming and diving found that all victims were known to be good swimmers or divers and the victims were almost exclusively men (56 cases).[5] Victims were often involved in a competition in which they wanted to "beat" someone else's or their own underwater distance record. The number of fatalities in that particular medical case series was high (23 cases).

Anecdotal observations suggest that underwater breath-holding is a relatively common practice in Australia. The practice is particularly dangerous if coupled with prior hyperventilation. This report provides further evidence that hyperventilating before breath-holding should be discouraged. Swimming pool authorities should be made aware of the potentially dangerous consequences, as should, arguably, children and adults undergoing basic swimming training.

Lessons from practice

- Syncope can manifest as seizure-like activity.
- Hypercapnic respiratory drive is important in breath-hold diving and swimming.
- Hyperventilation before breath-hold diving reduces hypercapnic respiratory drive and can result in anoxic loss of consciousness.
- Hyperventilation is the main causative factor in the development of hypoxia and syncope in underwater breath-holding.
- Loss of consciousness underwater can lead to drowning — the danger of underwater breath-holding is an important public health and safety issue that warrants increased awareness among the general public. ◆

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Competing interests

None identified.

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