

Blackout

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I am not a big fan of the term "shallow water blackout." Many blackouts just coincidentally occur in shallow water. That does not make them a special case. The term has been described in so many ways by so many people that it is meaningless, so this is the last time you will see this term here. I prefer terms that are clear and easy for everyone to understand and communicate.

"Gases dissolve, diffuse, and react according to their partial pressures, and not according to their [concentrations](#) in gas mixtures or liquids."^[1] There is a certain minimum arterial O₂ partial pressure (PaO₂) that is required in the cerebral blood supply in order to maintain consciousness and proper brain function. If PaO₂ drops below that (about 15-20 mmHg) for whatever reason, blackout is inevitable.^[2]

The conditions we will discuss here generally affect PaO₂ uniformly throughout the body. Where this is not the case, we will isolate cerebral PaO₂ and discuss it specifically.

I am not discussing arterial O₂ saturation for three reasons -

1. In normal blood, arterial O₂ saturation roughly follows PO_{2(lungs)} and PaO₂. You can see this relationship in the [Oxygen-hemoglobin dissociation curve](#). Note that this curve shifts under varying pH and CO₂ conditions in the blood.^{[3][4][5]}
2. PaO₂ is the value that directly affects the ability of brain tissues to use the oxygen in the blood.^{[1][2]}
3. For simplicity.

There are fundamentally three different types of blackouts in freediving:

1. *Duration-induced blackout*: As you hold your breath, oxygen is consumed, and because you are not breathing and replenishing your oxygen supply, PaO₂ drops. If you hold your breath long enough, and PaO₂ falls below that necessary for consciousness, blackout will occur.^[2]

Factors that affect this kind of blackout:

- a. Exertion during the breath hold will accelerate the use of oxygen. This can make blackout happen earlier.
- b. Hyperventilation prior to the breath hold reduces blood CO₂. This shifts the [Oxygen-hemoglobin dissociation curve](#). The [Bohr Effect](#) increases hemoglobin's affinity for O₂, reducing oxygen availability to brain tissues toward the end of the breath hold. This can make blackout happen earlier.^[4]

c. Hyperventilation prior to the breath hold delays your urge to breathe, making it easier for you to hold your breath until you blackout.^[9]

Duration-induced blackout can occur at any depth.

2. *Ischemic blackout*: This blackout is caused by a reduction in the blood flow to the brain (ischemia). There are a couple of ways to get there in freediving:

a. Hyperventilation reduces the amount of CO₂ in the blood. The body senses low CO₂ and induces cerebral vasoconstriction, reducing blood flow to the brain.^[6]

b. Packing increases the pressure on the heart and blood vessels in the chest. This can reduce blood flow, and particularly blood flow to the brain.^[7]

c. If you both hyperventilate and pack, this kind of blackout becomes even more likely.

When this happens, there is less oxygenated blood supplied to the brain. The situation can occur that the brain uses more oxygen than is available to it in the reduced blood supply, causing cerebral PaO₂ to fall. Blackout occurs if cerebral PaO₂ drops below that required to sustain consciousness.^[2] This type of blackout usually occurs early in the breath hold.

3. *Ascent-induced blackout*: This is caused during ascent from a dive by a drop in PaO₂ to a level below that needed to support proper brain function and consciousness. As you dive deeper and submergence pressure increases, PaO₂ increases too, easily sustaining consciousness. While at depth, some of the body's oxygen is used up. Any exertion during this time will accelerate oxygen depletion. If you stay deep too long, you could suffer a *duration-induced blackout* there. At some point though, assuming you are still conscious, you will ascend, and PaO₂ will drop again. If you consumed too much oxygen during the dive, PaO₂ will drop below that necessary for consciousness, and you WILL blackout.^[2] Once you begin your ascent, blackout can occur at any depth that PaO₂ reaches the critical level - deep, shallow, or anywhere in between. This might also be called the "hypoxic-at-depth-but-didn't-know-it blackout."

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