Diving into the Ice Bucket Challenge: Intraparenchymal Hemorrhage and the Mammalian Diving Reflex

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Abstract

Triggered by facial exposure to cold water and apnea, the mammalian diving reflex consists of bradycardia and peripheral arteriolar vasoconstriction leading to an increase in central arterial pressure. It has been previously associated with ischemic stroke but not definitively with intracerebral hemorrhage. We present a case of intracerebral hemorrhage occurring in a woman with poorly controlled hypertension following her participation in the amyotrophic lateral sclerosis fund-raising "Ice Bucket Challenge," in which ice-cold water was poured on her head. We suspect that facial exposure to ice-cold water triggered the diving reflex, causing a hypertensive surge and ultimately the intracerebral hemorrhage.

Keywords

cerebral hemorrhage, amyotrophic lateral sclerosis, diving, hypertension, ice

Introduction

The mammalian diving reflex, activated upon exposure of the face to cold water along with apnea, is associated with well-established cardiovascular changes including bradycardia and peripheral arteriolar vasoconstriction leading to hypertension.^{1,2} It has been previously associated with ischemic stroke³⁻⁷ but not conclusively with intracerebral hemorrhage. A 67-year-old woman developed a basal ganglia hemorrhage minutes after participating in the amyotrophic lateral sclerosis (ALS) "Ice Bucket Challenge." Officially sanctioned by the ALS Society and recently popularized by social media, Challenge participants must either donate US\$100 to the ALS Society or allow a bucket of ice water to be poured on their head. In this patient's case, the diving reflex elicited by the Ice Bucket Challenge most likely exacerbated her known hypertension which in turn caused the hemorrhage. This case demonstrates that intracerebral hemorrhage may occur as a complication of the diving reflex.

Case Report

A 67-year-old woman with poorly controlled hypertension and prior right occipital lobe infarction developed acute left hemiparesis and dysarthria 10 minutes after completing the ALS Ice Bucket Challenge—a recently popular fund-raising mechanism also designed to promote awareness for ALS (Figure 1).

The patient's systolic blood pressures on presentation to the emergency department were 170s to 190s. Computed tomography (CT) of the head demonstrated a 23 mL intracerebral hemorrhage centered in the right putamen. Coagulation factors and platelets were within normal limits and she took no antithrombotic medications. She was treated with intravenous labetalol and nicardipine and intubated for airway protection.

Computed tomography angiography of the head and neck did not reveal a vascular lesion but unfortunately showed enlargement of the hemorrhage to 37 mL, despite aggressive hypertension management. Repeat CT a few hours later showed stability of the hemorrhage (Figure 2). She was extubated on the second hospital day and transitioned to oral

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Figure 1. Still frame image from video of patient having ice-cold water poured on her head.

Figure 2. Axial (A) and coronal (B) computed tomography images show an acute intracerebral hemorrhage in the right putamen. Encephalomalacia in the right occipital lobe is due to an unrelated prior cerebral infarction.

antihypertensive medication. The patient's symptoms gradually improved and she was discharged to a rehabilitation hospital.

Discussion

The location of this patient's hemorrhage and lack of an underlying lesion make hypertension the most likely cause. We suspect that cerebral arterial hypertension was exacerbated as a result of the diving reflex, which was itself triggered by facial exposure to a cold stimulus. This hypothesis is supported by the close proximity between the patient's participation in the Challenge and the onset of neurologic symptoms.

The diving reflex is most robust in aquatic mammals but also occurs in air-breathing terrestrial animals (including humans).² Elicited by submersion of the head in cold water with coincident involuntary or voluntary apnea, the reflex is characterized by specific cardiovascular responses that

include bradycardia, peripheral vasoconstriction, and central hypertension with a gradual (over 1 minute) rise in mean arterial blood pressure.^{1,2} It is mediated via trigeminal afferents (in particular, the ophthalmic division)⁸ and vagus nerve and sympathetic efferents. Similar cardiac, vascular, and respiratory changes have been triggered not only by full-submersion breath-holding diving but also by both isolated facial submersion and isolated facial exposure to cold stimuli.^{1,2,9,10} Direct contact of water on the face is the most potent stimulus.²

Cold stimuli may play a role in the development of cerebrovascular disease. One study demonstrated that falling temperature and colder weather were associated with an increased risk of aneurysmal subarachnoid hemorrhage.¹¹ In addition, while not explicitly linked to the diving reflex, cases of intracerebral hemorrhage have occurred in the context of cold weather that have been thought to be due to surges in blood pressure.¹²

Some associations between diving and cerebrovascular disease have been documented. There are 2 reported cases of internal carotid artery dissection and stroke following scuba diving, one of these occurring in the context of a rapid ascent to the surface.^{3,4} Ischemic stroke has also been reported in the setting of a patent foramen ovale (PFO) in 1 diver who made a rapid ascent; his breath-holding was thought to cause a right-to-left shunting of blood through the PFO and thus the arterIALIZATION of bubbles that accumulated in his venous blood during his ascent.⁵ In addition, studies have also documented symptomatic and asymptomatic cerebral infarcts in divers compared to control patients.^{6,7}

Despite the patient's baseline hypertension, hemorrhage location, and temporal relationship of the Ice Bucket Challenge with the development of the bleed, we cannot necessarily prove that the diving reflex triggered by the Challenge caused the hemorrhage. Although the patient's blood pressure was high on arrival to the hospital, we do not know her vital signs at the time the bleed started. It is of course conceivable that the hemorrhage would have occurred regardless of the patient's participation in the Challenge.

Although the ALS Ice Bucket Challenge promotes a worthy cause and has been remarkably successful in raising money for research, this case warns us that the rise in blood pressure accompanying elicitation of the diving reflex can lead to unintended and dangerous consequences and thus suggests that those individuals with underlying medical conditions such as hypertension and prior cerebrovascular disease should consider alternate means of participation in the Challenge.

Authors' Note

The patient discussed in this article or their surrogate was shown the final version of the manuscript and consented to its publication. Because we present a case report and not research on humans, institutional review board approval is not required. The coauthors Kathleen McKee and Sarah Nelson contributed equally to this study.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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