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Exposure to 16 h of normobaric hypoxia induces ionic edema in the healthy brain

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Following prolonged exposure to hypoxic conditions, for example, due to ascent to high altitude, stroke, or traumatic brain injury, cerebral edema can develop. The exact nature and genesis of hypoxia-induced edema in healthy individuals remain unresolved. We examined the effects of prolonged, normobaric hypoxia, induced by 16 h of exposure to simulated high altitude, on healthy brains using proton, dynamic contrast enhanced, and sodium MRI. This dual approach allowed us to directly measure key factors in the development of hypoxia-induced brain edema: (1) Sodium signals as a surrogate of the distribution of electrolytes within the cerebral tissue and (2) K^{trans} as a marker of blood–brain-barrier integrity. The measurements point toward an accumulation of sodium ions in extra- but not in intracellular space in combination with an intact endothelium. Both findings in combination are indicative of ionic extracellular edema, a subtype of cerebral edema that was only recently specified as an intermittent, yet distinct stage between cytotoxic and vasogenic edemas. In sum, here a combination of imaging techniques demonstrates the development of ionic edemas following prolonged normobaric hypoxia in agreement with cascadic models of edema formation.

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