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Dynamics of the hypoxia—induced tissue edema in the rat barrel cortex in vitro

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Abstract

© 2018 Juzekaeva, Gainutdinov, Mukhtarov and Khazipov. Cerebral edema is a major, life threatening complication of ischemic brain damage. Previous studies using brain slices have revealed that cellular swelling and a concomitant increase in tissue transparency starts within minutes of the onset of metabolic insult in association with collective anoxic spreading depolarization (aSD). However, the dynamics of tissue swelling in brain slices under ischemia-like conditions remain elusive. Here, we explored the dynamics of brain tissue swelling induced by oxygen-glucose deprivation (OGD) in submerged rat barrel cortex slices. Video monitoring of the vertical and horizontal position of fluorescent dye-filled neurons and contrast slice surface imaging revealed elevation of the slice surface and a horizontal displacement of the cortical tissue during OGD. The OGD-induced tissue movement was also associated with an expansion of the slice borders. Tissue swelling started several minutes after aSD and continued during reperfusion with normal solution. Thirty minutes after aSD, slice borders had expanded by ~130 µm and the slice surface had moved up to attain a height of ~70 µm above control levels, which corresponded to a volume increase of ~30%. Hyperosmotic sucrose solution partially reduced the OGD-induced slice swelling. Thus, OGD-induced cortical slice tissue swelling in brain slices in vitro recapitulates many features of ischemic cerebral edema in vivo, its onset is tightly linked to aSD and it develops at a relatively slow pace after aSD. We propose that this model of cerebral edema in vitro could be useful for the exploration of the pathophysiological mechanisms underlying ischemic cerebral edema and in the search for an efficient treatment to this devastating condition.

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Keywords

Brain ischemia, Cortex, Edema, Hypoxia, Swelling

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