sion profile of primary human cerebral endothelial cells. FASEB J. V. 16. P.589.

Kluge M.A., Fetterman J.L., Vita J.A. 2013. Mitochondria and endothelial function. Circ. Res. V. 112. P. 1171.

Kluger M.S., Clark P.R., Tellides G., Gerke V., Pober J.S. 2013. Claudin-5 controls intercellular barriers of human dermal microvascular but not human umbilical vein endothelial cells. Arterioscler. Thromb. Vasc. Biol. V. 33. P. 489.

Martins E., Silva V., Lemos A., Palmeira A., Puthongking P., Sousa E., Rocha-Pereira C., Ghanem C.I., Carmo H., Remião F., Silva R. 2019. Newly Synthesized oxygenated xanthones as potential p-glycoprotein activators: *In vitro, ex vivo*, and *in silico* studies. Molecules. V. 24. P. 707.

Matthews R.T., Yang L., Browne S., Baik M., Beal M.F. 1998. Coenzyme Q10 administration increases brain mitochondrial concentrations and exerts neuroprotective effects. Proc. Natl. Acad. Sci. USA. V. 95. P. 8892.

Miller D.S., Cannon R.E. 2014. Signaling pathways that regulate basal ABC transporter activity at the blood-brain barrier. Curr. Pharm. Des. V. 20. P. 1463.

Miller D.S., Nobmann S.N., Gutmann H., Toeroek M., Drewe J., Fricker G. 2000. Xenobiotic transport across isolated brain microvessels studied by confocal microscopy. Mol. Pharmacol. V. 58. P. 1357.

More V.R., Campos C.R., Evans R.A., Oliver K.D., Chan G.N., Miller D.S., Cannon R.E. 2017. PPAR-α, a lipid-sensing transcription factor, regulates blood-brain barrier efflux transporter expression. J. Cereb. Blood Flow Metab. V. 37. P. 1199.

Nitta T., Hata M., Gotoh S., Seo Y., Sasaki H., Hashimoto N., Furuse M., Tsukita S. 2003. Size-selective loosening of the blood-brain barrier in claudin-5-deficient mice. J. Cell Biol. V. 161. P. 653.

Salmina A.B., Kuvacheva N.V., Komleva Y.K., Pozhilenkova E.A., Lopatina O.L., Gorina Y.V., Petrova L.L., Morgun A.V., Taranushenko T.E. 2015. Glycolysis-mediated control of blood-brain barrier development and function. V. 64. P. 174.

Sanchez-Covarrubias L., Slosky L.M., Thompson B.J., Davis T.P., Ronaldson P.T. 2014. Transporters at CNS barrier sites: obstacles or opportunities for drug delivery? Current Pharm. Design. V. 20. P. 1422.

Sena L.A., Chandel N.S. 2012. Physiological roles of mitochondrial reactive oxygen species. Molecular Cell. V. 48. P. 158.

Shapoval N., Obolenskaia O., Kalenikova E., Gorodetskaya E., Medvedev O. 2018. Tissue distribution and redox status of coenzyme Q10 after intravenous administration of ubiquinol to rat. J. Hypertension. V. 36. P. 149.

Sharom F.J. 2008. ABC multidrug transporters: Structure, function and role in chemoresistance. Pharmacogenomics. V. 9. P. 105.

Smith C.W. 2008. Adhesion molecules and receptors. J. Allergy Clin. Immunol. V. 121. P. 375.

Sun J., Zhu H., Wang X., Gao Q., Li Z., Huang H. 2019. CoQ10 ameliorates mitochondrial dysfunction in diabetic nephropathy through mitophagy. J Endocrinol. JOE-18-0578.R1.
https://doi.org/10.1530/JOE-18-0578

Tatsuta Y., Kasai K., Maruyama C., Hamano Y., Matsuo K., Taira S. 2017. Imaging mass spectrometry analysis of ubiquinol localization in the mouse brain following short-term administration. Sci. Reports. V. 7. P. 1.

Tsai H.Y., Lin C.P., Huang P.H., Fan Y., Deng X. 2016. Coenzyme Q10 attenuates high glucose-induced endothelial progenitor cell dysfunction through AMP-activated protein kinase pathways. J. Diabetes Res. 6384759.
https://doi.org/10.1155/2016/6384759

Tsuneki H., Sekizaki N., Suzuki T., Kobayashi S., Wada T., Okamoto T., Kimura I., Sasaoka T. 2007. Coenzyme Q10 prevents high glucose-induced oxidative stress in human umbilical vein endothelial cells. Eur. J. Pharmacol. V. 566. P. 1.

Zhang H., Chang Z., Mehmood K., Abbas R. Z., Nabi F., Rehman M.U., Wu X., Tian X., Yuan X., Li Z., Zhou D. 2018. Nano copper induces apoptosis in PK-15 cells via a mitochondria-mediated pathway. Biol. Trace. Elem. Res. V. 181. P. 62.

Zhou S.F. 2008. Structure, function and regulation of p-glycoprotein and its clinical relevance in drug disposition. Xenobiotica. V. 38. P. 802.

THE EFFECT OF UBIQUINOL ON CEREBRAL ENDOTHELIAL CELLS IN DIFFERENT REGIONS OF RAT BRAIN

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The ability of the promising antioxidant and neuroprotective medicine coenzyme Q10 to penetrate the blood-brain barrier (BBB) makes it a potential agent that can influence the mitochondrial metabolism of brain cells. Of particular interest is its reduced form – ubiquinol, which can affect the structural and functional activity of cells that form the BBB. However, the mechanisms of penetration, actions and effects of the drug on brain cells are not fully understood. The aim of our work was to study the effect of ubiquinol on the expression of endothelial permeability mark-

ers, dense contact proteins, and apoptosis processes in various rat brain structures. The study evaluated the effect of coenzyme Q10 on CD31, Pgp, CLDN5 and apoptosis in sections of different parts of the rat brain after a single intravenous injection of ubiquinol at a dose of 30 mg/kg. Our results suggest that ubiquinol causes an increase in CD31 expression in the entorhinal cortex from 2 to 24 hours after exposure, followed by an increase in CLDN5 expression from 96 to 192 hours of exposure. It is noteworthy that in the amygdala of the brain, an increase in CD31 expression was accompanied by a delayed decrease in CLDN5 expression, while in the hippocampus, we registered only a decrease in CLDN5 expression. Our data on the decrease in apoptosis intensity do not allow us to say what contribution to this effect is made by cerebral endotheliocytes, but the detected signs of angiogenesis intensification and region-specific changes in the integrity of the BBB under the action of ubiquinol allow us to consider It as a promising agent for correcting BBB dysfunction in brain diseases.

Keywords: coenzyme Q10, ubiquinol, P-glycoprotein, CD31, claudin, apoptosis, angiogenesis, cytoadherence, tight junctions