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Numerical Model of Brain and Systemic Temperature during local Hypothermia for Ischemic Stroke Treatment

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Introduction: Therapeutic hypothermia (TH) has the potential to decrease cerebral damage caused by ischemic stroke. Systemic approaches based on surface or intravenacaval cooling entail the risk of side effects like infection, arrhythmia and shivering. Additionally, a prolonged time to target temperature may lead to insufficient cooling in the critical reperfusion phase after mechanical thrombectomy (MT). Recently, an intracarotid cooling sheath was developed to induce local TH in the penumbra before recanalization using the cooling effect of cranial blood flow via collaterals. We developed and applied a numerical computational model to predict the brain temperature and systemic effect.

Material & methods: Penne"s bio-heat-equation was simplified for a fast estimation of the time dependent intracranial and systemic temperature. The systemic body temperature was used as inlet temperature for the cooling sheath, which was considered to have a constant cooling power. Calculation was performed considering three different penumbra perfusion rates.

Results: Depending on the respective perfusion rate, the resulting decrease of the brain temperature after 10 min was in a range of 1.3 to 2 K. The maximum decrease of body temperature was approx. 0.3 K after 1 h cooling.

Conclusion: The predicted brain temperature decrease underlines the potential of intracarotid cooling to achieve locale TH in the reperfusion phase during MT procedure. The perfusion rate within the penumbra is a strong determinant for the intracranial temperature curve. The systemic temperature drop is moderate but indirectly effects the brain temperature at longer cooling times.