Detecting Impaired and Intact Cerebral Autoregulation to Monitor Intracranial Pressure for Noninvasive Sensing

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Traumatic Brain Injury (TBI) is a major cause of death (~160 / day) and disability in the US. Autoregulation (AR) maintains the cerebral blood flow (CBF) despite changes in cerebral perfusion pressure. Impaired AR and abnormal intracranial pressure (ICP) can be fatal or lead to hospitalization. A child in a car crash, who suffered from subdural hemorrhage, died because it was detected only after five hours. Currently, impaired AR is detected by measuring abnormal ICP using invasive methods that have proven to be unsafe for patients. Noninvasive methods, however, are inaccurate. I researched a method to noninvasively monitor CBF and provide an alert for impaired AR. I conducted experiments to simulate cerebral blood flow rate (~650-700 ml/min) by modeling the brain using a balloon, blood vessels using silicone and polyvinylchloride plastic tubing (to match skin thermal conductivity and thickness/radius) and blood using a 10% glycerol solution (to match blood viscosity). The flow rate was transduced to surface temperature change that was measured using both a thermocouple and a thermistor. The blood flow rate was linearly correlated to temperature change and resistance change measured by the thermocouple (voltage: ~0.3mv) and the thermistor (transduced voltage: ~15mv) respectively. I designed a breadboard prototype using a thermistor to power a vibration motor to alert patients for unsafe ICP. This system costs only ~$100. In the future, I propose to build a neck brace for continuous noninvasive monitoring with a vibration alert to track CBF and ICP, allowing effective treatment and timely avoidance of secondary problems.

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