MODELING AND MONITORING CEREBRAL PERFUSION IN PREDICTING G-LOC

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G-induced loss of consciousness (G-LoC) has been identified as the cause of a number of disasters related to high performance fighter aircrafts, racing cars and amusement park-rides. It is known to be caused by cerebral hypoxia due to insufficient oxygenated blood reaching the brain. G-LoC is said to be a protective reflex, where the brain ceases activity in the higher centres and switches to minimum metabolism to preserve function in the lower centres to control breathing and heart rate. Knowledge of the blood flow to the brain at a given point in time, as well as the rate of change, may allow prediction of G-LOC. With this objective and proposition, we developed a physiological model of the body's response to high G loading to permit estimation of the current ATP and O_2 reserves in the brain based on the brain physiology, blood oxygen saturation, and cardiovascular systems biology. Current methods for measurement of brain function during high G manoeuvres include EEG and blood haemoxymetry. Both these methods share the shortcoming that once brainwave activity or blood oxygen content change, the pilot/racer will already be experiencing either G-LoC or a related phenomenon, almost-loss of consciousness A-LoC, with a corresponding reduction in reasoning ability. Integration of on-line sensing using Doppler Ultrasound is proposed to calibrate and measure the cerebral perfusion at low and high G force loading and the change of flow-rate. The initial experiments are conducted using a mechatronic jig incorporating automated probe positioning and a biological phantom with known pulsatile flow using a geared flow pump.

The model is based on the three-element Windkessel model and demonstrates the entire blood flow rate of the human body under high acceleration exposure. The gravity tolerance and G-LOC are obtained from the simulation of cerebral blood flow by comparing the physiological limitations. The model indicated that the gravity tolerance could be affected by the cardiac output variation which was calculated through the heart-rate variation during the acceleration process. It used the minimum blood and oxygen supply as a reference to calculate the gravity tolerance under different cardiac outputs. It also analyzes the viscosity variation influence on blood flow rate at different acceleration onset rates.

Speaker's brief biosketch:

Dr. Sunita Chauhan is presently working as an Associate Professor at the Mechatronics and Design Div., School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore. She obtained her PhD, DIC in Medical Robotics from Imperial College of Science Technology and Medicine, London, UK in 1999. Her current research interests include Medical/Surgical Robotics, Computer Assisted and Integrated Surgery, Medical Ultrasound (Imaging, Therapeutic and Surgical ultrasound), Bio-sensors, Image and Sensor data processing/fusion/interpretation. She is a member of many professional organizations – Sr. member IEEE (RAS &WIE), UIA, ISTU, life member IACAS.