A DYNAMIC TECHNIQUE FOR THE QUANTITATION OF OXYGEN UTILIZATION RATES USING POSITRON EMISSION TOMOGRAPHY (PARTITION COEFFICIENT, RADIONUCLIDES, TIME-OF-FLIGHT)

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The conversion of oxygen to water in oxidative phosphorylation is required for the efficient production of adenosine triphosphate. This process can be monitored externally using oxygen-15 and positron emission tomography to allow estimation of metabolic rate in the human brain. A dynamic technique using ('15)O-O(,2) has been developed and compared to the existing steady state and autoradiographic approaches. These currently employed methods suffer from pitfalls associated with using assumed values for the tissue-blood partition coefficient of water. Computer simulations have been performed demonstrating the underestimation of physiological rates with the steady state technique and the time varying solutions of the autoradiographic approach. Experimental data agrees with the predicted behavior of each of these methods.

The new technique requires the estimation of local cerebral blood volume and the tissue-blood partition coefficient value of water. The blood volume, necessary for a blood radioactivity correction, is estimated from the equilibrium distribution of ('15)O-CO. The tissue-blood partition coefficient is calculated using a rapid least squares analysis of ('15)O-H(,2)O dynamic blood flow data. The measured values of blood volume and partition coefficient are assumed to remain invariant with changes in the physiological state of the brain. The metabolic rate is then estimated by fitting the oxygen model to the observed kinetics in a one minute breathhold study.

Alternatives to arterial blood sampling have been considered. Expired breath and lung activity concentrations used in conjunction with arterial blood sample data provide the required input functions. A time-of-flight probe has been developed as a non-invasive alternative and some intial measurements with the system are presented.

The experimental data are in good agreement with the model predictions supporting the switch to a dynamic technique for the estimation of oxygen utilization rate using ('15)O-O(,2). The dynamic technique has been implemented providing both oxygen utilization rate and blood flow estimation from a single study.