Decomposition characteristics of brain tissue investigated at two different temperatures by means of ^{1}H-MRS

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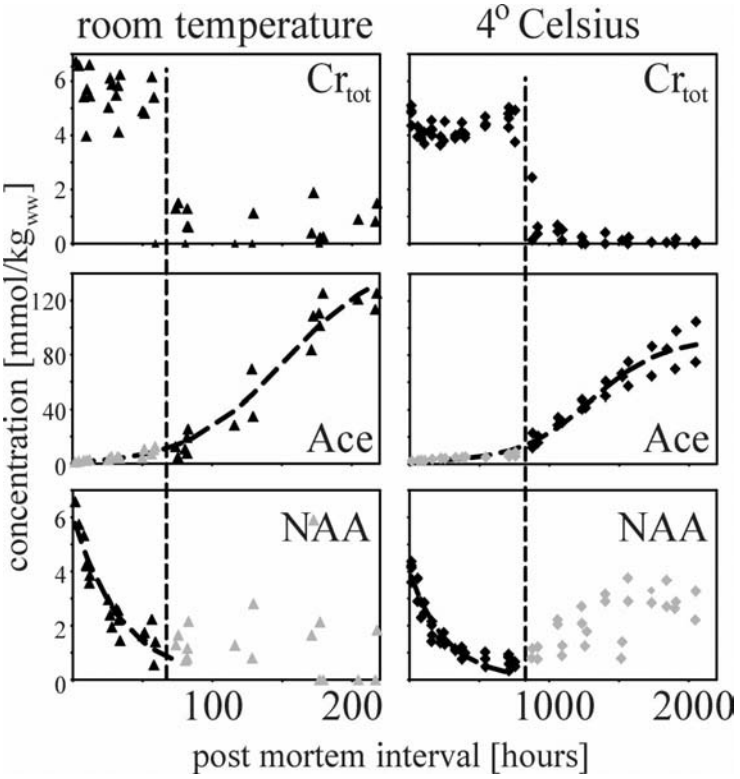
Introduction: It has been shown that decomposition of brain tissue can be characterized by ^{1}H-MRS [1], which allows for a reliable estimation of the postmortem interval (PMI) [2]. A sheep model was used to characterize the decomposition of brain tissue at room temperature (RT), where the concentration changes of several metabolites have shown reproducible time courses. The determination of PMI is of enormous relevance in legal medicine; however, it is known that biochemical processes and, therefore, the determination of PMI strongly depend on ambient temperature. In order to quantify the influence of different temperatures, the present work aims at an evaluation of the concentration behavior of various metabolites at 4°C compared to RT and, hence, at the extension of the current model from RT to 4ºC.

Methods: Single-voxel ^{1}H-MRS (TR=3s, TE=20ms, water and outer volume suppression) was used to investigate brain decomposition in 8 sheep heads at 21±3ºC and in 4 sheep heads at 4±2ºC. Spectra were recorded on a 1.5 Tesla whole body scanner (GE SIGNA) using a conventional quadrature head coil. The sheep heads were stored in a plastic container during the entire period of investigation (at RT up to 18 days and at 4ºC up to 85 days). Details about the experimental design concerning the eight sheep heads measured at RT have already been given in detail in [1&2]. The sheep heads at 4ºC were stored in a temperature controlled refrigerator. Voxels of 10×10×15mm^3 were placed in the parieto-occipital region of the brain (ipsi- and contralateral side). Spectra were quantified with LC-Model [3] using an extended basis set of metabolites [1] and the fully relaxed water signal as internal reference standard. For practical reasons, the water concentration was assumed to remain constant.



Results: The figure illustrates concentration changes of 3 selected metabolites, total Creatine (Creatine + Phosphocreatine; Cr_{tot}), Acetate (Ace) and N-acetyl-aspartate + N-acetyl-aspartyl-glutamate (NAA) during decomposition. Concentration changes over postmortem time from the sheep heads stored at RT (shown on the left) are compared to the results from decomposition at 4ºC (right column). Considering results at one temperature only (i.e. left and right column separately), the concentration of each metabolite shows a different temporal behavior. However, comparing the time courses of a specific metabolite at RT and at 4ºC, the variations show the same behavior, though on a different time scale. At RT the Cr_{tot} concentration decreases suddenly after about 70h, whereas at 4ºC this drop can not be observed until 800h postmortem. Also at the same points in time (indicated with the dashed vertical line) it can be observed for both temperatures that the increase of the Ace concentration becomes more pronounced and the NAA concentration drops below detection limit (values in gray are excluded from the analysis since they are below detection limit or overlapped by other resonances).

The dashed curves in the graphs represent mathematical functions fitted to the data. In the case of Ace a three parameter logistic function was fitted to the entire data set, whereas the NAA data can be described by an exponential decrease. In the latter case the function was fitted only to the data represented by the black symbols.

Discussion: The data shown in the figure illustrate that the concentration of each of the 3 selected metabolites follows its own characteristic temporal behavior that is similar at different temperatures, however, at a completely different time scale. The selection of these 3 metabolites shall demonstrate how the combination of all three metabolites can lead to an unequivocal estimation of PMI at different temperatures. As an isolated observation, the step-like concentration behavior of Cr_{tot} could not be used for an estimation of the PMI. However, Cr_{tot} represents an ideal separator between the two different phases (1) if Cr_{tot} is above 3 mmol/kg$_{ww}$, NAA represents an optimal estimator while (2) if Cr_{tot} is below 3 mmol/kg$_{ww}$, the evaluation can be based on the temporal development of Ace.

Conclusions: The three examples of metabolites demonstrate that PMI estimation by means of ^{1}H-MRS is also feasible at temperatures different from RT, which is of great practical relevance. If accounting for the temperature dependent kinetics, it even appears that the same mathematical models could be used.

References: **[1]** Ith M et al. Magn Reson Med 2002;**48**:915-920; **[2]** Scheurer E et al. NMR Biomed 2005;**18**:163-172; **[3]** Provencher SW et al. Magn Reson Med 1993;**30**:672-679