Quantitative determination of postmortem intervals: in situ ^{1}H-MR spectroscopy of human brain compared to traditional forensic methods

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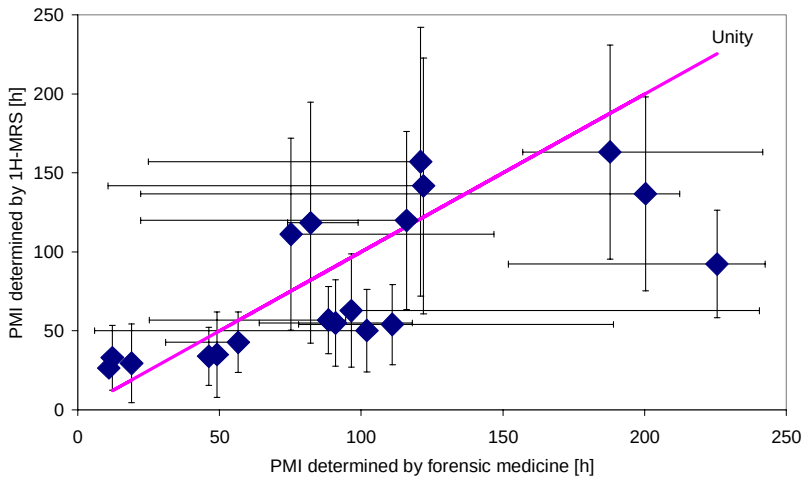
Introduction: The determination of the postmortem interval (PMI) in forensic medicine has an enormous impact on legal, criminalistic, and psychological processes. Body temperature, livor and rigor mortis can be used during the initial 36h after death, however, estimation of the time since death in the later postmortem period almost exclusively bases on vague criminalistic information and a subjective interpretation of putrefactions signs. This leads to an uncertainty concerning the real time of death that is often in the order of several days. In situ ^{1}H-MRS of decomposing brain in an animal model revealed that some metabolites show unequivocal concentration changes over at least 3 weeks postmortem [1]. It has been demonstrated in this sheep model that a calculation of PMI by inverse parameterized functions describing the time course of metabolite concentrations is possible [2]. However, one of the crucial questions is how far the conclusions and values from the sheep model can be transferred to human cases. Therefore, the present work aims at a comparison of calculated PMI's based on in situ ^{1}H-MR spectra of human brain and standard metabolite curves from the sheep model [2] to PMI's determined by traditional forensic methods.

Materials & Methods: *Human bodies:* In situ brain spectra were acquired from 32 human bodies from the Institute of Forensic Medicine with PMI's of 11–920 h postmortem. Human bodies have been chosen for MRS examination according to the following criteria: scull and brain not injured, good prospect of getting criminalistic information about the conditions and time of death. PMI's determined by traditional forensic methods based on body core temperature, livor and rigor mortis, putrefaction signs and criminalistic information. Determination of PMI by MRS consisted of the quantitation of 10 metabolites and the calculation of PMI by inverse parameterized functions. *Spectroscopy:* Single voxel ^{1}H-MRS was performed at 1.5 T on a whole body scanner (GE SIGNA) using a conventional quadrature head coil. Spectra were acquired with a short echo time PRESS sequence (TR=3s, TE=20ms) with water and outer volume suppression. In most of the cases the voxel was placed in the centrum semiovale. Spectra were quantified using the fully relaxed water signal as internal concentration standard [2] and fitted with LCModel. Concentrations of NAA + NAAG have been corrected for the higher in vivo concentrations of these metabolites in humans compared to sheep brain.

Results: Thirteen out of the 32 cases had to be excluded from further analysis, either because the forensic PMI range remained excessively large after criminalistic investigation had been completed or due to extreme temperature conditions during the postmortem period. The figure compares the PMI's of 19 human bodies determined by traditional forensic methods (diamonds placed at the most probable point in time based on criminalistic evidence) with calculated PMI's. Data are well distributed over the analyzed interval up to 250h postmortem. Including the rightmost point at 225h, linear regression leads to PMI(MRS) = 0.557·PMI(forensic) + 26.9 h, R = 0.708, p(slope) < 0.001, and p(intercept) = 0.09, while an exclusion of the rightmost point improves the linear correlation to PMI(MRS) = 0.731·PMI(forensic) + 14.8, R = 0.794, p(slope) < 0.001, and p(intercept) = 0.32. Generally the uncertainty of forensic PMI's is very large. In half of the cases upper and lower limits cover more than 72h, culminating in one case with a possible time span of almost 8 days.

Discussion & Conclusion: Earlier studies in a sheep model [2] have shown that ^{1}H-MR spectra allow for a reliable determination of PMI's up to about 250 h. The exceedingly large error bars of forensic PMI's demonstrate an inherent problem and show that the determination of PMI's in forensic medicine is often very unprecise covering time spans of several days or even weeks. Therefore, it is not realistic to define standard metabolite curves directly in humans and the need of an animal model with known time of death is obvious. Furthermore, the current study shows that standard curves determined in our sheep model can be used to calculate PMI's of human bodies: the correlation between MRS and forensic PMI's up to 200 h is reasonable with a correlation coefficient of 0.794, even though a gold standard for validation of MRS data concerning real times since death is missing. Slightly smaller PMI's determined from ^{1}H-MR spectra could be explained by a systematic overestimation of the forensic PMI because humans who are not found within short time after death often live in social isolation, where no witnesses could provide information concerning the longest possible PMI.



It is concluded that PMI's can be calculated with reasonable accuracy by in situ ^{1}H-MRS of the human brain up to PMI's of 200 h with data from the sheep model available so far.

Acknowledgments: Supported by Swiss National Foundation (31-059082) and Gebert-Rüf Foundation (GRS-069/99).

References: [1] Ith M et al., Magn. Reson. Med. 48: 915-920, 2002; [2] Scheurer E et al., Proc. ISMRM 11: 568, 2003.