NEW TECHNIQUES FOR THE THERMAL PHYSIOLOGIST: USING CLINICAL MAGNETIC RESONANCE METHODS IN BASIC RESEARCH

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Magnetic resonance imaging (MRI) has become a powerful tool in non-invasive diagnosis of pathological and pathophysiological phenomena. Its main advantages are the use of non-ionizing radiation and the possibility to adjust the contrast of the images according to the tissues and phenomena involved. Imaging is disturbed by movements (body movements, respiration, blood flow) and by temperature changes. The latter effect may be converted into a measurement principle, it one remains aware that it will be highly disturbed by "imaging", i.e. when measuring within different tissues and of course also by movements including perfusion. Basically, it is a technique delivering relative units, i. e. it has to be calibrated e. g. by fiberoptical measurements. Five techniques have been proposed and tested: Temperature dependence of 1. spin-lattice relaxation time ("T_1"), 2. Brownian motion (diffusion coefficient), 3. resonance frequency of protons, 4. equilibrium magnetization ("M_o"), 5. chemical shift of temperature sensitive complexes (lanthanides).

In contrast to the great number of studies on dead material, the successful application of temperature measurements in living organisms is still rather rare, mainly beause of many additional problems. The measurements of T_1 in vivo proved to be difficult because it is disturbed by changes of proton density and of perfusion. One disadvantage of diffusion imaging is the anisothropy of the diffusion coefficient, meaning that the temperature dependence of the signal changes according to the direction of cells or fibers. Disadvantages of the use of lanthanide complexes include restricted spatial resolution and the invasiveness of the intravenous application of the agent. The proton resonance frequency method requires a complex image processing, including, like other methods, subtraction of different images. No detailed information seems to be availabe for the equilibrium magnetization methods. A common problem of most methods is the still long acquisition time, so that the requirement for no movement cannot be fulfilled. However, the development of fast MRI procedures and algorithms is an incredibly quick process which promises a continuous improvement. Nevertheless, at present, temperature measurement in vivo is not a routine procedure at all. Our lab focussed on temperature imaging of muscle, in vitro and in vivo, using spin-echo sequences making use both of the "T_1" and the "M_o"-effect. The method proved to be less sensitive to motions than others with a high signal to noise ratio, the disadvantage still being the long acquisition time (about 5 min) and the interference with blood flow. If these drawbacks are of lower significance or cabn be overcome, an in vivo accuracy of less than 1°C can be expected, together with a good spatial resolution. With further progress in this technology, there is no doubt that it will assist enormously in revealing some of the central secrets within the thermoregulatory system.

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