LOCALISATION OF METABOLITES IN ANIMAL AND HUMAN TISSUES USING ^{31}P TOPICAL MAGNETIC RESONANCE

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Topical Magnetic Resonance is a new technique for acquiring high resolution ^{31}P NMR spectra from a selected, localised region within a living animal. No surgery is required yet the metabolic state of a variety of internal tissues and organs can still be studied. In the presence of a suitable combination of static field gradients the magnetic field can be profiled to delineate a homogeneous and an inhomogeneous region. Around the origin there will be a roughly spherical volume of homogeneous field the diameter of which can be controlled by variation of the static gradients. Any object or part of an object placed within this sensitive volume will produce high resolution NMR spectra which are separable from the broadened spectra produced from the surrounding volume.

Experiments were first performed using intact, anaesthetized rats at 73.8 MHz in a spectrometer system with a working bore of 42 mm (1). ^{31}P NMR spectra, characteristic of the liver were observed and global liver ischaemia could be diagnosed in a non-invasive manner. More recent experiments have been performed at 32.5 MHz in a system with a working bore of 200 mm which can accommodate larger animals and human limbs. One simple experiment is shown in Figure 1 where the spectra obtained from human forearm muscle are presented. Signals from adenosine triphosphate (ATP), phosphocreatine (PCr) and inorganic phosphate (P_i) are clearly identifiable. Spectrum 1a shows the resonances obtained from normal, resting muscle whereas spectrum 1b shows the same resonanes approximately 11 minutes after the application of a tourniquet to the upper arm. Spectrum 1c is the difference between 1b and 1a and shows the increased P_i level and decreased PCr level in the muscle tissue as a result of the reduction of the blood supply.

Figure 2 shows a time course experiment which monitors the application (at the origin) and removal (after 18.7 mins) of the tourniquet during a 30 minute period. The breakdown and subsequent regeneration of PCr corresponds to a rise and fall of the P_i level. There was no detectable change in the tissue pH from its initial value of 7.1 ± 0.1.

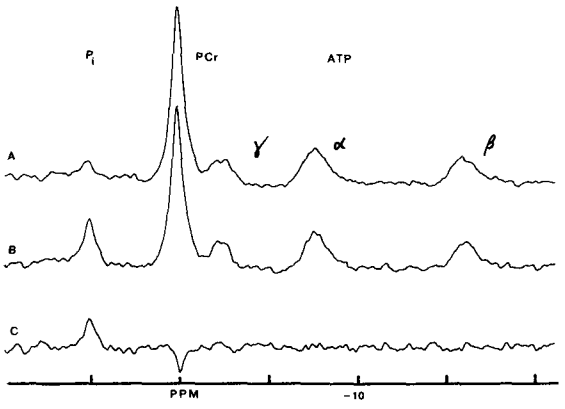

Figure 1: ^{31}P spectrum of palmaris longus muscle obtained from 40 mm diameter sensitive volume using a surface coil (2). The broad component in each raw spectrum was removed by convolution difference (3). Line broadenings of 7.5 Hz and 15 Hz were used. (a) Spectrum of normal resting muscle (128 scans at 5 secs) (b) Spectrum obtained under same conditions as (a) with tourniquet applied (c) Difference of (b) - (c).

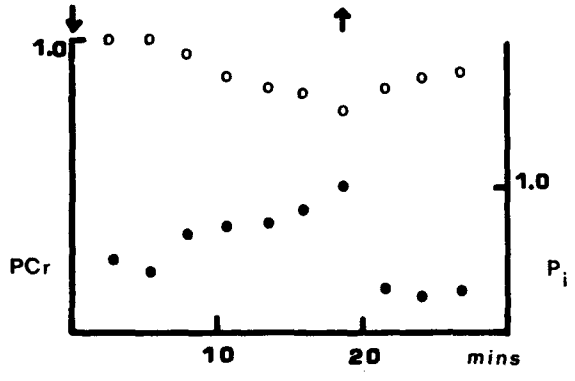

Figure 2: The variation of PCr (O) and Pi (●) during the application (↓) and removal (↑) of a tourniquet. The ordinates correspond to normalised peak heights after sequential groups of 32 scans of 5 secs.

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