Main glossary

Aa

AB systems

Referring to molecules exhibiting multiply split MRS peaks due to spin-spin interactions. In an AB system, the chemical shift between the spins is of similar magnitude to the splitting constant (J). A common example is citrate (abundant in the normal prostate). Citrate consists of two pairs of methylene protons (A and B, see Appendix VI) that are strongly coupled such that:

$$\nu_A - \nu_B = 0.5\, J$$

where ν_A, ν_B are the resonating frequencies of the two protons. A tall central doublet is split into two smaller peaks either side, which are not usually resolved in vivo at 1.5 tesla. Citrate exhibits strong echo modulation.

See also J-coupling and AX systems.

Reference R. B. Mulkern & J. L. Bowers (1994). Density matrix calculations of AB spectra from multipulse sequences: quantum mechanics meets spectroscopy. *Concepts Magn. Reson.* **6**, 1–23.

Absolute peak area quantification

MR spectroscopy method of using peak area ratios where the denominator is the water peak. The areas are adjusted for differences in relaxation times, and the actual concentration of the metabolite is determined from:

$$[m] = [w] \times \frac{2}{n} \times \frac{S_0^m}{S_0^w}$$

where [w] is the concentration of water and S_0 are the peak area amplitudes of the metabolite and water signals at equilibrium, i.e. having been corrected for relaxation, which has occurred at the finite time of measurement. The factor $2/n$ corrects for the number of protons contributing to the signal (here 2 is for water).

Note: [w] is taken as 55.55 Mol/kg.

Reference P. B. Barker, B. J. Soher, S. J. Blackband, J. C. Chatham, V. P. Mathews & R. N. Bryan (1993). Quantitation of proton NMR spectra of the human brain using tissue water as an internal concentration reference. *NMR Biomed.* **6**, 89–94.

Acoustic noise

The audible noise produced by the scanner. Caused by vibrations in the gradient coils induced by the rapidly oscillating currents passing through them in the presence of the main magnetic field. Ear protection must by worn by patients because of this noise. Gradient-intensive sequences, e.g. 3-D GRE, EPI, produce the highest noise levels. Typically, the recorded noise level may be weighted (dB (A) scale) to account for the frequency response of the human ear. Values of 115 dB (A) have been recorded with EPI. The Lorentz force, and therefore noise level, increases with field strength (typically a 6 dB increase from 1.5 to 3.0 tesla). Current methods to combat noise include mounting the gradient coils to the floor to reduce vibrations and lining the bore with a vacuum. More sophisticated measures include active noise reduction.

See also bore liner and vacuum bore.

Reference F. G. Shellock, M. Ziarati, D. Atkinson & D. Y. Chen (1998). Determination of gradient magnetic field-induced acoustic noise associated with the use of echoplanar and three-dimensional fast spin echo techniques. *J. Magn. Reson. Imag.* **8**, 1154.

Acquisition time

Time taken to acquire an MR image. For a spin-echo sequence it is given by:

$$N_p \times N_A \times TR$$

where N_p is the number of phase encoding steps, N_A is the number of signal averages, and TR is the repetition time. Shorter scan times means a trade-off in image quality in terms of resolution (N_p), SNR (N_A) and contrast (TR). Scan times may also be reduced by using parallel imaging.

In gradient-echo sequences with very short TR times, the above equation includes a factor for the number of slices acquired.

Active noise reduction

Advanced method of reducing gradient noise produced from the scanner. Utilises force-balanced coils, which are designed so that the Lorentz forces act in a symmetrical manner to counteract the vibrations. May offer up to 30 dB improvement.

See also acoustic noise.

Reference R. W. Bowtell & P. M. Mansfield (1995). Quiet transverse gradient coils: Lorentz force balancing designs using geometric similitude. *Magn. Reson. Med.* **34**, 494.

Active shielding

Refers to either shielding of the main magnetic field or the gradient coils. The fringe field may be actively shielded using an additional set of coil windings around the main set, with a current of opposite polarity passing through it. An unshielded 7 tesla scanner has a 5 gauss fringe field of 23 m.

See also passive shielding.

Actively shielded gradients are now standard on all systems. This reduces eddy currents in the cryogen and other conducting structures.

Active shimming

Improving the homogeneity of the main magnetic field (the shim) by passing current through additional sets of coils within the scanner to augment the field. Typically, 12 to 18 sets of coils are used which affect the field in each orthogonal direction. A first-order shim changes the field in a linear fashion, a second-order shim produces field changes that vary with the square of distance and so on (higher-order shims). The shim coils themselves may be resistive or superconducting.

See also passive shimming.

ADC

Apparent diffusion coefficient. Refers to the measurable value of diffusion rather than the actual value due to the effects of cell boundaries, etc. The signal attenuation observed in a diffusion-weighted image due to the apparent diffusion

coefficient, D, is:

$$S = S_0.\exp(-\mathrm{b}\,D)$$

where b is the gradient factor (see *b*-factor).

The ADC value for water is approximately 2.0×10^{-3} mm^2 s^{-1}.

Not to be confused with the analogue-to-digital converter (ADC) which digitises the measured MR signal before further processing.

Reference B. Issa (2002). In vivo measurement of the apparent diffusion coefficient in normal and malignant prostatic tissues using echo-planar imaging. *J. Magn. Reson. Imag.*, **16**, 196–200.

ADC map

A parameter map in which the pixel intensity is equal to the value of ADC. The map may be obtained from images acquired at several different values of *b*-factor. Care must be taken in selecting a minimum *b* value as flow effects dominate at very low *b*. Alternatively, a two-point method may be used typically acquiring a $b = 0$ image and a second image at a high *b* value. ADC maps have proved useful in diagnosing stroke but do not provide any directional information.

See also *DTI*.

Adiabatic pulse

Specific use of a variable frequency excitation pulse which is swept through the Larmor frequency. These pulses are less sensitive to B_1 inhomogeneities than conventional pulses but take longer to apply. Used in continuous wave NMR.

Agarose gel

Common material used in the construction of phantoms. Its T_2 relaxivity (10 mM^{-1} s^{-1}) is much higher than corresponding values for T_1 (0.05 mM^{-1} s^{-1}), which means T_2 values can be made to vary considerably with little alteration in T_1. The material is often mixed with Gd-DTPA to produce phantoms with a range of T_1 and T_2 values.

See also gel phantom.

Reference M. D. Mitchell, H. L. Kundell, L. Zxel & P. M. Joseph. (1986). Agarose as a tissue equivalent phantom material for NMR imaging. *Magn. Reson. Imag.*, **4**, 263–266.

AIF

Arterial input function. This is the signal-time characteristic of the contrast agent bolus in the blood, and may be used to model uptake in other tissues. For best results, an artery near to the site of interest needs to be selected for the appropriate AIF. This function can be deconvolved from tissue or tumour enhancement to quantitate perfusion.

See also dynamic scanning and perfusion imaging.

Alanine

Proton spectroscopy peak with a resonance at 1.48 ppm. It is often seen to increase in meningiomas.

Aliasing

Image artefact caused by anatomy extending beyond the imaging field of view but within the sensitive volume of the RF

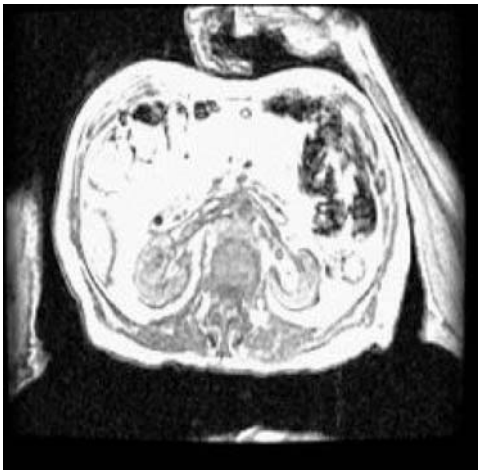

Figure 1. Phase wrap or **aliasing** results in the top of the hand appearing at the bottom of this image.

coil. It results in the offending part of the anatomy being incorrectly mis-mapped onto the opposite side of the image. Frequency oversampling usually ensures aliasing is only possible in the phase direction and can be avoided by swapping the direction of encoding. It is also referred to as wrap and foldover.

See also no phase wrap, frequency wrap and nyquist frequency.

Alignment

Referring to the direction of the net magnetisation vector when it is parallel to B_0, i.e. the situation prior to the first excitation pulse.

Angiogenesis

Phenomenon typical of tumours where new blood vessel growth is induced (mediated by angiogenic factors) to meet the increased oxygen demand required for rapid development. This is utilised in contrast enhanced scanning in cancer, where the preferential uptake of contrast agent by tumours improves its differentiation from normal tissue.

AngioMARK

Commercial name of a blood-pool agent undergoing clinical trials (Epix, Cambridge, MA). Also known as MS-325, it binds to albumin to extend its vascular half-life. The T_1 relaxivity is approximately ten times that of Gd-DTPA.

Anisotropy

Diffusion that is not the same in each direction, i.e. not isotropic. Usually implies some preferred diffusion direction and therefore can be used to elucidate structural information, e.g. white matter fibre tracts in the brain.

See also tensor, tractography and fractional anisotropy.

Anisotropic resolution describes spatial resolution that is not similar in each direction, e.g. in 2-D imaging where slice thickness is much greater than the in-plane resolution.

Anterior

Referring to the front side of the patient anatomy. It is at the top of an axial image and on the left of a sagittal image (see Figure 2).

See also posterior.

Apodisation

Essential part of processing MR spectroscopy data. It involves the multiplication of the free induction decay signal by an appropriate filter to improve signal-to-noise and reduce truncation artefacts in the final spectrum. Common filters include exponential, Lorentzian (a more rounded shape) and Gaussian (bell-shaped). Filters may typically have a linewidth of between 2 and 4 Hz.

Spatial apodisation reduces voxel–voxel contamination (voxel bleeding) in CSI.

Apparent diffusion coefficient

See ADC.

Array

A combination of RF surface coils to improve imaging coverage, taking advantage of the superior signal-to-noise of a single element without the compromise of poor sensitivity.

In a phased array design, consideration of the overlapping profiles has to be taken into account. Phased array coils, like surface coils, are typically used as receive-only coils (using the body coil to transmit). Coil arrays are now important in parallel imaging techniques.

Arrhythmia rejection window

The time interval in the cardiac cycle during which no imaging is acquired.

See also gating.