1. Fat relax rapidly compared to water, why?

Answer:

T1 relaxation rate depends on the number of the molecules tumbling at the resonant frequency. The fat molecules have slower tumbling rate compared with water. That is, they have longer correlation time than that of water molecule (10^{-12} sec). At the range of MR imaging frequency, there will be larger number fat molecules per unit tumbling at the resonant frequency than that of the water molecules. So the T1 relaxation rate of fat is larger than that of water.

T2 relaxation rate depends on the static magnetic inhomogeneity and dynamic spin exchange. The dynamic dipole-dipole coupling is more important than the static effect. The density (12% w/w) of protons in the fat molecule is higher than that (11% w/w) of water. That means there are more chances of spin exchange in fat. It will cause larger T2 relaxation rate of fat.

2. T2 of nonpolar storage fat is longer than that of many other tissues, why?

The anisotropic rotation of the molecule will shorten T2. Compared with many other tissues, the nonpolar storage fat is more isotropic, so it has long T2 relaxation time.

3. How about lipids in brain?

The lipids in the brain are polar with hydrophobic and hydrophilic chains. They organized into bilayer sheets by their interaction with water. These sheets prevent the lipids molecule rotating in an isotropic fashion. The lacking of motional narrowing cause rapid T2 dephasing. So the lipids in the brain have short T2.