

Summary

The aim of the research presented in this doctoral dissertation (based on a series of attached publications) is to analyse Nuclear Magnetic Resonance (NMR) relaxation processes in low magnetic fields (ranging from milli Tesla to 0.25 T) for selected human tissues, with the goal of determining to what extent differences in the relaxation properties of pathological and reference tissues may potentially be useful in medical diagnostics. As part of this research, an extensive set of experimental data was collected, including the proton (^1H) spin–lattice relaxation rates over a resonance frequency range from approximately 10 kHz to 10 MHz (corresponding to the given magnetic field range), as well as spin–spin relaxation rates measured at the resonance frequency of 18.7 MHz. These experiments were conducted for endometrial (P2) and lung (P3) tissues. To compare the relaxation properties of cancerous and reference tissues, a dedicated data analysis strategy was developed. This approach involves determining specific parameters defined as markers of relaxation properties. The strategy was presented in publication P1 and illustrated using experimental material (spin–lattice relaxation rates in the frequency range 1 kHz–10 MHz) for colon tissues collected by the research team at the University of Aberdeen and shared with me as part of a scientific collaboration. The proposed set of parameters includes quantities such as proton spin–lattice and spin–spin relaxation rates (in the case of frequently observed bi-exponential relaxation processes, the relaxation rates corresponding to both components were analysed, along with the amplitude ratio of the two components and the ratio of the individual relaxation rates), the slope of the relaxation rate versus resonance frequency curve (assuming a linear approximation in the low-field region), and the relative decrease in relaxation rate with an increase in magnetic field (resonance frequency) by one decade. After analysing the data in study P2, it was confirmed that spin–spin relaxation in endometrial tissues exhibits a bi-exponential character, while spin–lattice relaxation follows a mono-exponential pattern. Moreover, the slope of the relaxation rate versus resonance frequency curve was found to be, on average, twice as large in the low-frequency range. In study P3, the analysis of lung tissue data showed that the ratio of relaxation rates for pathological-to-reference tissue pairs was 1.15. The obtained results confirm that analysis NMR relaxation processes at low magnetic fields is a valuable tool for characterizing molecular dynamics in tissues