VARIABILITY OF T1 AND T2 OF PROTONS IN SOLUTIONS OF IRON (III) COMPLEXES.&

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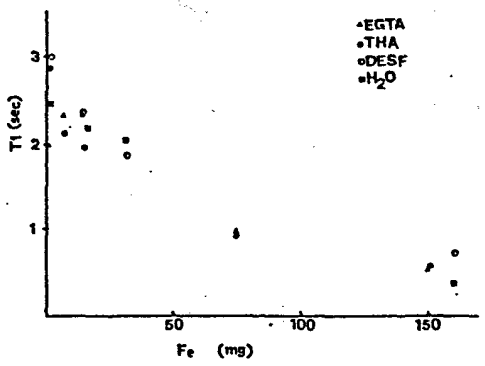
INTRODUCTION

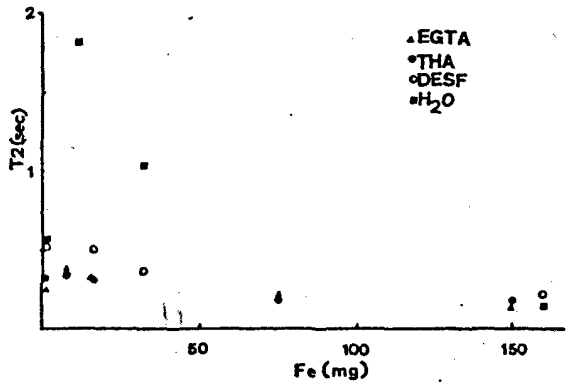
In Nuclear Magnetic Resonance signal intensity is mainly dependent on the resonating hydrogen density and, at different extent, on the T1 and T2 relaxation times. Variations of these parameters produce changes in signal intensity and thereby cause percetible contrast changes on NMR images.



The signal intensity also depends on instrumental parameters, including the selected imaging sequences and the receiver gain. While the relative intensities of two regions in any imaged section will vary with different operator-selectable imaging sequences, the observable relaxation times as the resonanting proton density, represent physical characteristics of the tissues that are independent on machine parameters . Therefore, the measurement of T1 and T2 has been sought as one of the fundamental ways of characterizing tissue. At this purpose it is claimed that an adeguate choise of pulse sequences leads to images which are determined by T1 values without any direct influence of T2 values or proton density and viceversa for pure T2 image. Our aim in this paper will be to point out some aspects of T1 and T2 measurement in relation with particular NMR imaging sequenes.

MATERIALS AND METHODS

Data were obtained by imaging on a 0.5 T Siemens a phantom constituted of sixteen cylindrical sample tubes containing solution of selected iron (III) complexes at different concentrations just to obtain T1 and T2 values spanning the range of medical interest.



The concentrations of ferric ions were chosen from 2 to 300 mg/l and the following ligands were used: Desferoxamine, EGTA, Triethylenetetraamine -hexacetic acid (THA). Concentrated solutions were obtained by dissolving weighted quantities of iron trichloride and excess of the appropriate ligand in distilled water. The chemistry of iron (III) aqueous solutions has been subject of several studies and its easy hydrolizability with formation of polinuclear species is well known. The presence in solution of ligand has been reported to strongly prevent the polimerization of the hydrolitic species and also to reduce the hydrolysis itself.

As for as the present complexes are concerned, it appears reasonable to assume that both the low iron concentration and the presence of the ligand should result in a predominant influence of the ligand on the affectiviness of the relaxation iron(III)-aqueous protons.

All images were obtained using a spin-echo pulse sequence with repetition of the radiofrequency signal at 35 and 70 msec after the 90° RF pulse (TE parameters). Several RF repetition times (TR parameters) were used. Thus, several spin echo images were obtained at each section.

NMR spin echo signal intensity is related to the T1 and T2 values by the following equation:

$$I=n(H)f(v)\exp(-TE/T2)(1-\exp(-TR/T1)$$

where n(H) is the local nuclear spin-density and f(v) is a function of proton motion.

This approximated equation is valid when exp(-TR/T2) approaches zero, i.e. for TR$\gg$T2. As this equation predicts, T1 shortening or T2 prolungation will increase signal intensities . If both T1 and T2 are shortened , intensity may either increase or decrease depending on which relaxation effect, T1 or T2, dominates.

T1 values were calculated using the intensity of one of the echo sampling of two different TRs:

$$\frac{I1}{I2}=\frac{(1-\exp(-TR1-N1xTE))/T1)}{(1-\exp(-TR2-N2xTE))/T2)}$$

Ni is the total echo number of the measurement from which image i was derived.

The T2 calculations were carried out on the basis of two images with different echo times according to the following formula:

$$I2=\frac{(TE1-TE2)}{\ln(I1-I2)}$$

The matrix size was 256X256 on a slice 10 mm thick.

RESULTS

The mean values of T1 and T2 relaxation times calculated in samples at different level of iron chelators are shown in fig 1 and 2. The dependence is almost tipical of the beaviour of proton relaxation influenced by paramagnetic ions. It is worthnoting the peculiar and not understood enhancement of T2 corresponding to concentrations of Fe below 30 mg.

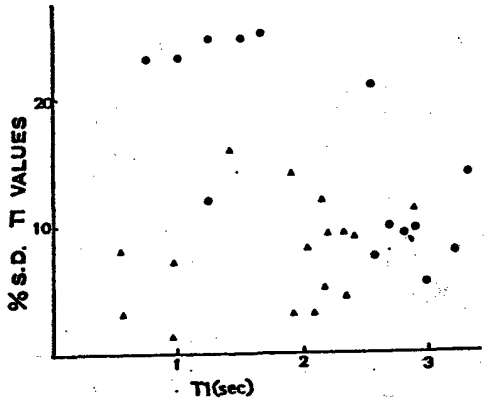
Figures 3 and 4 report the standard devations(SDs) of T1 and T2 measurements relative to the magnitude of T1 and T2 values, respectively.

T1 means and variations are obtained from two separate sets of experiments performed with TR ratios of 800/2000, 800/4000, 2000/4000 msec the first one and 600/1000, 600/2200 and 1400/2200 the second one.

TE was 35 msec for all data .

SDs of T1 values are less for calculations with images obtained using the second group of TR ratios.

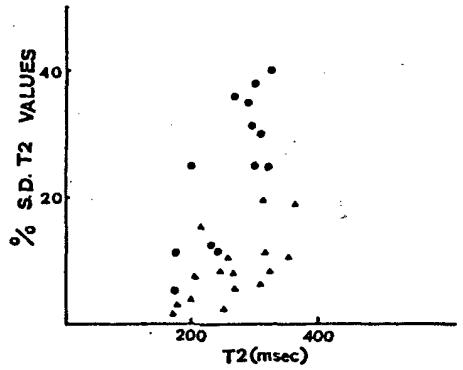
T2 means and relatives SDs were calculated using two echo samples 35 and 70 msec, and for each group of data presented in figures 800, 2000, 4000 msec (●) and 600, 1000, 1400 and 2000 msec (▲) TR sequences respectively. In both cases SDs is less for samples of short T2 relaxation times and higher for long T2. As for T1 results SDs are less for experimental values obtained with the second group of TR sequences (▲).



Worthnoting is the fact that the amount of variability of T1 and T2 relaxation times depends on the magnitude of the relaxation time values themselves.

Our results confirm the inherent limitations in accurate measurements of T1 and T2 during routine

imaging sequences. It is our aim to choise of the TR and TE setting of the imager to obtain the most reproducible results for substances with T1 and T2 relaxation values similar to most tissues.



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