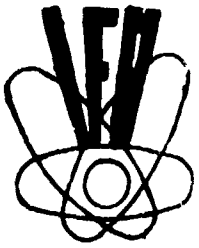

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THE INFLUENCE OF THE pH OF THE TISSUES ON THE TRANSVERSE RELAXATION TIME T_2

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THE INFLUENCE OF THE pH OF THE TISSUES ON THE TRANSVERSE RELAXATION TIME T_2 *)

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Abs Spin-echo nuclear magnetic resonance measurements may be used as a method for studying the influence of pH upon T_2. The transverse relaxation time T_2 was measured on Ehrlich ascites and Ehrlich solid tumors. An increase of T_2 with 184 ms in the case of Ehrlich ascites and 16 ms for Ehrlich solid tumor could be observed when the pH values decrease. The data are in accordance with a model that explains the change of T_2 with the tetanic isometric contraction.

INTRODUCTION

The application of nuclear magnetic resonance (NMP) spectroscopy in the study of tissues has provided information concerning the physical state of tissue water /1,2/.

The influence of some disturbing factors as paramagnetic impurities, nonuniform sample packing and magnetic field inhomogeneity of the spectrometer, upon spin-spin relaxation time T_2 was reported elsewhere /3/.

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*) Work presented at the Fifth International Symposium on Magnetic Resonance, Bombay, India, Jan. 1974.

In the work described here we have employed spin-echo NMR techniques to obtain information about the dependence of T_2 on tissue pH. The modification of T_2 with the tetanic isometric contraction is explained by T_2 dependence on pH /4/.

The relaxation time T_2 was measured on Ehrlich ascites and Ehrlich solid tumors.

MATERIAL AND METHODS

Proton nuclear magnetic relaxation times were measured at room temperature (293 $\pm$ 1°K) at 60 MHz using a standard NMR pulsed spectrometer Bruker B-KR 322s. The transverse relaxation time was measured with the usual Carr-Purcell /5/ method as modified by Meiboom and Gill /6/. The 90° and 180° pulse widths were 2.5 and 5 microseconds respectively.

The measurements were carried out only on the "slow", liquid-like part of the signal, the fast decaying portion was in general of negligible amplitude and no attempt was made to study it.

The biological samples were put into standard sample tubes of 8 mm o.d.

The pH was measured with a Radiometer Copenhagen pH meter immediately after the ascites were collected.

The determinations were done at 0 and 40 minutes after administration of the glucose solution.

RESULTS AND DISCUSSION

Our measurements of relaxation times T_1 and T_2 of double distilled water at various pH values are shown in Fig.1. These results are in good agreement with those obtained by Meiboom /7/. The relaxation time T_2 is pH dependent, but T_1 is not pH dependent. It is to be noted that the greatest difference existing between T_1 and T_2 was found at pH 7.

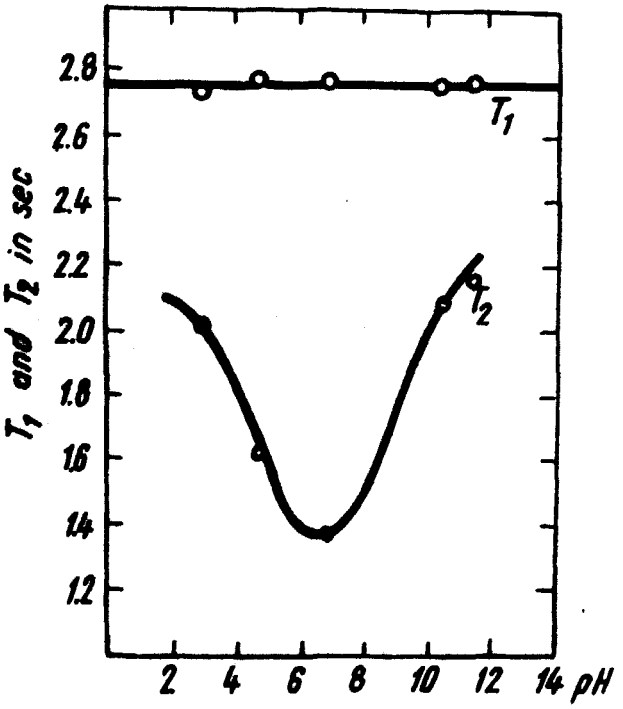

Fig.1.

Our measurements of the relaxation time T_2 on Ehrlich ascites tumor showed an increase from 180 msec to 364 msec when the pH decreased from 6.9 to 5.9 following the administration of glucose. T_2 increased from 28 msec to 44 msec for solid Ehrlich tumor.

Bratton et al /4/ carried out NMR studies of frog skeletal muscle. Pulse methods were used to find T_1 and T_2. T_1 did not change with the state of the muscle (relaxation or tetanic contraction). In condition of tetanic, isometric contraction T_2 increased from 40 msec in the relaxed state to more than 60 msec in a state of exhaustion. They explained their data with a two-phase model in which the more tightly bound phase did not affect the longitudinal relaxation (T_1) and the observed change of T_2 was due to a shift of water out of the bound phase.

Cooke and Wien /8/ observed no change in proton relaxation times T_1 and T_2 when heavy meromyosin was bound to actin, when myofibrils were contracted with adenosine triphosphate (ATP), or when globular actin was polymerized. Their measurements of proton relaxation times indicated that no significant change in protein hydration occurs during the functional interactions of the muscle proteins.

There is an alternative explanation for Bratton's results, however.

The modification of T_2 reported by Bratton et al. is due to the pH decrease which follows the isometric contractions. In our measurements on Ehrlich solid tumor an increase of T_2 with 16 msec following the glucose administration was observed. This has the same magnitude as that observed by Bratton, 20 msec.

CONCLUSIONS

a) The relaxation time T_2 of tissue water protons is pH dependent.

b) The increase of T_2 with tetanic, isometric contraction from 40 msec in the relaxed state to more than 60 msec in a state of exhaustion could be explained by the dependence of T_2 on pH.

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