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Application of Nuclear Resonance Scattering for *In Vivo* Measurements, *L. Wielopolski, D. Vartsky, S. H. Cohn (BNL)*

Information on the elemental composition of the human body is of considerable importance in clinical practice and medical research. One of the methods for determination of human body composition is nuclear resonance scattering (NRS) of gamma rays.[1-3]

The resonance scattering technique depends on full-energy scattering of gamma radiation with the level in the nucleus of the element to be measured. Resonance can be achieved by using gamma radiation from a gaseous source that decays to an excited state of a stable isotope of the element to be measured. Under these circumstances, the recoil energy loss is "regained" as a result of the energy transfer to the "target" nucleus.

NRS is applied in our laboratory to measure hepatic and cardiac iron overload. The setup is shown schematically in Fig. 1. For iron analysis, a gaseous source of 4 mg $MnCl_2$ is introduced into an evacuated quartz vial. Following irradiation in a nuclear reactor, ^{56}Mn decays by beta emission to the 847-keV level of ^{56}Fe, which subsequently decays to the ground state of ^{56}Fe with a 7 ps half-life. The resonance-scattered radiation is detected by two high-purity germanium detectors and processed by standard spectroscopy electronics.

The principal aim of this work is to evaluate the efficacy of the iron chelation therapy. Serial measurements over a time period of 6 to 12 months of a given patient will enable us to see how the iron is removed from the critical organs. Every time a new source is prepared, it is important to standardize properly the iron measurement. It was learned that, due to the interaction between the gaseous source and the wall of the vial, the resonance flux did not follow the natural decay time of ^{56}Mn ($t_{\frac{1}{2}}$ = 2.58 h). It was necessary, therefore, to monitor the incident resonance flux with an iron plate and to express the iron result normalized to resonance fluence rather than to radiation dose. Moreover, it was found that different vials interact differently with the gaseous radioactive source and result in a different time behavior of the resonance gamma flux.[3]

Results of iron measurements in 26 patients are summarized in Table I. For the sake of comparison, Table I includes the iron index, defined as the net counts in the iron peak per unit resonance fluence, and the iron concentration in milligrams of iron per gram of wet tissue. Converting the iron index to iron concentration requires the measurement of a phantom with a known concentration of iron in the organ and a correction of the patient reading for the overlying tissue attenuation relative to the phantom. The error involved in the iron concentration result is larger than that involved in the iron index. It is advantageous, therefore, to use the iron index results for any serial studies. It should be mentioned, however, that it is inaccurate to use the iron index results for population studies.

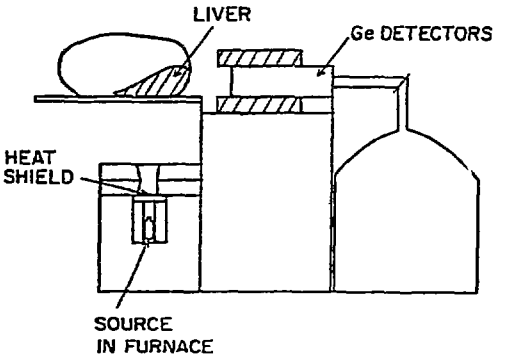

Fig. 1. Schematic illustration of the source, patient, and the detector for iron measurement in the liver by NRS.

Feasibility studies to measure copper[4] and chromium by NRS indicate that overloads of these metals are measurable *in vivo*. Basic information of the NRS measurements of iron, copper, and chromium is summarized in Table II. Detection limits are quoted for an absorbed dose of 1 rad to the skin surface.

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