The kinetics of Fe and Ca for the development of radiation-induced apoptosis by micro PIXE imaging

S. Harada[a], Y. Tamakawa[a], K. Ishii[b], A. Tanaka[b],T. Satoh[b], S. Matsuyama[b],
H. Yamazaki[b], T. Kamiya[c],T. Sakai[c], K. Arakawa[C]. M. Saitoh[c], S. Oikawa[d]
K. Sera[e]

a: Iwate Medical University, Department of Radiology
, 19-1 Uchimaru, Morioka, Iwate 020-8505 Japan.

b: Department of Quantum Science and Energy Engineering, Tohoku University
Sendai, 980-8579, Japan

c: Takasaki Radiation Chemistry Research Establishment, JAERI,
Takasaki, Gunma 370-1292, Japan

d: Ion Accelerator Corp., Hakodate 040-0076, Japan
e: Cyclotron Center, Iwate Medical University.
348-1 Tomegamori, Takizawa, Iwate 020-0173、*Japan*

Abstract

To study the interactions between the induction of radiation-induced apoptosis and trace elements kinetics, human leukemia cells were irradiated *in vitro* by ^{60}Co γ rays, after which the cells were evaluated for the detection of apoptosis and trace element (Fe, Ca, Zn) imaging was carried out. The frequency of apoptosis, i.e. the number of apoptotic bodies per 100 nuclei, was obtained by microscopic assay using TUNEL staining at 400X magnification. The trace element distribution in the cell was determined by micro-PIXE using 2 MeV proton beams. In the early phase of apoptosis, the maximum level of Fe accumulation was observed in the cell stroma. In the mid to end phase, Fe accumulation was diminished, and, instead, Ca accumulation increased and Zn decreased in the nucleus. There appear to be two steps for the development of apoptosis: 1) the signaling from cell stroma to nucleus by Fe ,
or an Fe-containing enzyme; and 2) the degeneration of the nucleus by Ca-dependent enzyme, and release of Zn from digested nucleus. Those strong accumulations may be new markers for apoptosis.