Protective effect of β-carotene on radiation-induced lipid peroxidation

S. Ramesh, Kailash Manda and A. L. Bhatia

Department of Zoology, University of Rajasthan, Jaipur 302 004, India

The effect of β-carotene against radiation-induced lipid peroxidation was studied in Swiss albino mice, which were administered oral dose of β-carotene for two weeks. After two weeks, the animals were exposed to 3 Gy of gamma radiation. The animals were sacrificed 24 h post exposure and liver and spleen were removed for the biochemical estimation of lipid peroxidation. The result indicates that β-carotene prevents the radiation-induced lipid peroxidation in mice liver and spleen.

LIPID peroxidation has been implicated in diseases such as atherosclerosis[1], cancer[2] and ageing[3]. It is known that ionizing radiation causes lipid peroxidation[4,5] and damages cellular macromolecules. There are some reports demonstrating the protective effects of β-carotene on radiation-induced DNA damage[6] and chromosomal aberrations[7]. However, there are no such reports on the membrane damage induced by radiation which is a major clastogen and capable of producing highly reactive oxygen intermediates implicated in various diseased conditions.

β-carotene, one of the carotenoids, has been thought of value to humans and other species not only as a precursor to vitamin A but also for having excellent antioxidant properties[8]. Besides being an antioxidant and precursor to vitamin A, β-carotene may be more important in our diet than vitamin A for the following reason. People with low tissue levels of β-carotene were found to be usually prone towards getting a number of different types of cancer[9]. Protection by β-carotene and related compounds against oxygen-mediated cytotoxicity and genotoxicity with respect to implications for carcinogenesis and anticarcinogenesis have been demonstrated[10,11]. As radiation damage also occurs due to the attack of free radicals on cell membranes, decrease or removal of free radicals might lead to a decrease in the extent of damage. The present study is hence an attempt to document the effect of β-carotene administration against gamma radiation-induced lipid peroxidation.

β-carotene and thiobarbituric acid were purchased from Sigma, USA. All other chemicals used were of analytical grade. Swiss albino mice were divided into four groups. The first group served as control (did not receive any treatment). The second group was administered β-carotene (50 mg/kg body weight) orally for two weeks. The third group was exposed to 3 Gy of gamma radiation to study the radiation-induced lipid peroxidation. The fourth group was administered β-carotene (50 mg/kg body weight) orally for two weeks. After treatment with β-carotene, the fourth group was exposed to 3 Gy of gamma radiation to study the effect of β-carotene against radiation-induced lipid peroxidation.

The animals were sacrificed 24 h after the radiation exposure. Liver and spleen were removed for the biochemical estimation of lipid peroxidation by the method of Okhawa *et al.*[12], using tetramethoxypropane (malondialdehyde) as the standard. Protein was estimated by the method of Bradford[13], using bovine serum albumin as the standard. Other groups were also sacrificed simultaneously. The endpoint has been expressed as thiobarbituric acid reactive substances (TBARS) or MDA equivalents.

Table 1 shows that radiation induced the lipid peroxidation as reflected by the TBARS equivalents content which increased in liver to 21.4 nmol/mg protein and in spleen to 25.7 nmol/mg protein. The values were statistically highly significant. However, when β-carotene-supplemented animals were exposed, no change in TBARS or MDA equivalents concentration was noted with respect to control (statistically insignificant difference). The β-carotene supplementation prevented the radiation-induced lipid peroxidation in liver and spleen, as statistically there is no significant difference between control and β-carotene-treated radiation-exposed animals.

The results show that the β-carotene renders protection against radiation-induced oxidative stress. Oxidative stress refers to the cytotoxic consequence of oxygen-free radicals – superoxide anions, hydroxyl radical and hydrogen peroxide, which are generated as by-products of normal and aberrant metabolic processes that utilize molecular oxygen[14]. It is well known that exposure of biological membrane to oxidative stress results in the progressive degeneration of membrane structure and loss of activity. The measurement of lipid peroxidation is thus a convenient method to monitor oxidative cell damage[15]. The products of lipid peroxidation such as malonaldehyde and 4-hydroxynonenal are toxic to the cell[16]. Lipid peroxidation within the membrane has a devastating effect on the functional state of the membrane

Table 1. Effect of β-carotene on radiation-induced lipid peroxidation (Values are mean ± SE of six animals in each group)

Treatment group	TBARS (nmol/mg protein)	
	Liver	Spleen
Control (I)	11.7 ± 0.37	13.3 ± 0.64
β-carotene treatment (II)	11.2 ± 0.42	12.9 ± 0.48
Radiation exposure only (III)	21.4 ± 0.61*	25.7 ± 0.57*
β-carotene + radiation (IV)	12.4 ± 0.51**	14.2 ± 0.41**

*Significantly different from control (I) and β-carotene treatment (II) at $P < 0.001$.
**Significantly different from group (III) but statistically insignificant from groups (I) and (II).

because it alters membrane fluidity, typically decreasing it and thereby allowing ions such as Ca^{++} to leak into the cell. The peroxyl radical formed from lipid peroxidation can attack membrane proteins and enzymes, besides that it reinitiates lipid peroxidation. The preservation of cellular membrane integrity depends on protection or repair mechanisms capable of neutralizing oxidative reactions. The reduction in the amount of TBARS or MDA equivalents in the β-carotene administered irradiated animals suggests that β-carotene may scavenge the free radicals formed during radiation exposure. It was reported earlier that orally administered β-carotene has a photoprotective function[17]. The antioxidative mechanism of β-carotene has been suggested to be singlet oxygen quenching, free radical scavenging and chain breaking during lipid peroxidation[8]. If carotenoids are to produce an antiradiation effect, it must be absorbed by the body and available in the tissues exposed to radiations. Adipose tissue, liver and plasma of humans were found to be the major pools of β-carotene[8]. β-carotene normally predominates among the most important carotenoids and is absorbed in the intestine. For humans one-sixth (on a weight basis) of the dietary β-carotene is estimated to be absorbed and converted to retinol whereas for other provitamin A carotenoids, about one-twelfth is absorbed and converted to retinol[18]. The present study does not rule out the possibility of antiradiation efficiency of β-carotene in preventing radiation-induced lipid peroxidation in liver and spleen of mouse. However, a correlative study of data and time with respect to recovery from the stress/damage is needed, which is under progress in our laboratory.

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