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LIPID PEROXIDATION

Abstract: This article explores how lipid peroxidation affects the integrity of the cell membrane. The biological landscape of this process is considered.

Key words: Peroxidation of lipids, free radicals, biological membranes, eukaryotic cells, cells

Lipid peroxidation is the oxidative degradation of lipids, which occurs mainly under the influence of free radicals.Lipid peroxidation mainly occurs in the biological membranes of both prokaryotic and eukaryotic cells.

Problems: the main mechanisms of cell damage determine nonspecific indicators of cell damage used for diagnostics, assessment of the functional state of damaged tissues and organs. Cellular damage mechanisms are central to the onset and development of disease.

Lipid peroxidation is a chain reaction that occurs at the expense of free radicals.

Free radicals are particles that have one or more unpaired electrons on their outer electron shell. The presence of an unpaired electron determines a high reactivity, because the radical strives to acquire the missing electron. In particular, two radicals easily combine with each other to form a new compound.

The source of lipid peroxidation is mainly unsaturated fatty acids. In animal cells, the main role is assigned to arachidonic acid (20: 4). In bacterial cells, due to the fact that arachidonic acid is absent, palmitooleic acid (16: 1) (structural formula number 3 in the Appendix) and very rarely cis - vaccenic acid (18: 1) (structural formula 4 in the Appendix). These acids are oxidized and give an electron to a free radical, in turn, a free radical of a fatty acid is formed, and that, in turn, takes one electron from another fatty acid and a chain reaction starts, which develops slowly at first, but as other fatty acid molecules are involved, the reaction rate is sharp is accelerating. Theoretically, this reaction will continue as long as there are substances in the membrane that can turn into free radicals. And, in simpler terms, all fatty acids and other lipoids capable of oxidation are not yet oxidized. Under normal conditions, this does not happen, since there are special substances and mechanisms in the body that can regulate these processes - inhibitors. Such substances are called antioxidants, and the enzyme system is called the antioxidant system.

Lipid peroxidation includes several stages:

1. Initiation.
2. Development.
3. Forking.
4. Open circuit.

Stage 1 lipid peroxidation. At the moment of initiation, for example, the methylene group located between the double bonds is attacked by a hydroxyl radical, and a hydrogen atom is knocked out, which reduces the hydroxyl radical to water. Further, in the fatty acid there is a rearrangement of the double bond, the displacement of the radical group and its interaction with oxygen. As a result, a lipoperoxyl radical is formed.

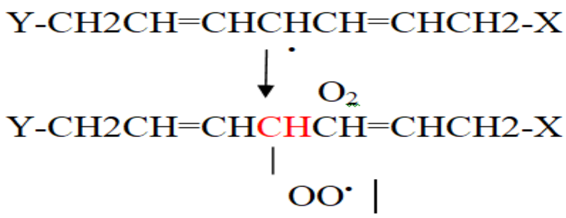
Y-CH2CH=CHCH2CH=CHCH2-X + HO$^{\bullet}$

Y-CH2CH=CHCHCH=CHCH2-X + H2O

L • - lipid radical

LH + HO$^{\bullet}$ → L$^{\bullet}$ + H2O

Stage 2 lipid peroxidation. The development of a linear chain reaction is the neutralization of the lipoperoxyl radical (LOO •) as a result of the interaction of this radical with neighboring fatty acids. Then converted to lipid hydroperoxide (LOOH).



LOO• - lipid peroxidation

$L^{\bullet} + O2 \rightarrow LOO^{\bullet}$
$LOO^{\bullet} + LH \rightarrow LOOH + L^{\bullet}$

The formation of lipid hydroperoxide is accompanied by the formation of a lipid radical (L •), which initiates chain continuation.

Stage 3 LP. Chain branching - decomposition of lipid hydroperoxide with an increase in the number of free radicals.

$LOOH \rightarrow LO^{\bullet} + HO^{\bullet}$
$LOOH + Fe^{2+} \rightarrow LO^{\bullet} + HO^{-} + Fe^{3+}$

A significant acceleration of lipid peroxidation is observed in the presence of small amounts of metal ions. As a rule, this is most often the ion of ferrous iron - Fe2 +.

Stage 4 LP. The chain reaction is terminated when radicals interact with each other or in a reaction with various antioxidants, for example, vitamin E (structural formula 5 in the Appendix), which donates electrons, while transforming into a rather stable oxidized form - tocopheryl radical. This radical is not involved in the development of the oxidation chain.

$LOO^{\bullet} + L^{\bullet} \rightarrow LOOL$
$L^{\bullet} + L^{\bullet} \rightarrow L–L$
$LOO^{\bullet}$ + vit E → LOOH + vit $E^{\bullet}$

The primary products of LP are fatty acid hydroperoxides and diene conjugates. Hydroperoxides further decompose with the formation of secondary products - malondialdehyde, triene conjugates.

Diene conjugate structure - CH=CH - CH=CH-

Structure of Triene Conjugates: -CH=CH - CH=CH - CH=CH-

The most reactive of the secondary LPO products is malondialdehyde (MDA), which is capable of forming covalent bonds with NH_2-groups of proteins and other molecules to form a Schiff base. Thus, malonic aldehyde forms the end products of lipid peroxidation. [3] The scheme of reaction with ε-NH_2-groups of lysine or N-terminal amino acids of proteins, with NH_2-groups of phospholipids and glycosamines is presented in the Appendix under number 6.

Antioxidants are substances that inhibit oxidation; any of the many chemicals, including natural products of the body and nutrients from food, which can neutralize the oxidative effects of free radicals and other substances. [5]

Antioxidant factors are divided into 2 types - enzymatic and non-enzymatic.

Non-enzymatic factors of the antioxidant defense of cells include vitamin E (tocopherols), group A provitamins (β-carotene), vitamin A (retinol), ubiquinone (coenzyme Q10), uric acid, glutathione, ceruloplasmin, selenium-containing and zinc-containing compounds, melatonin, ionol. However, it was found that most antioxidants have prooxidant properties, which depends on the concentration of these substances and the nature of neighboring molecules.

Enzymatic factors include:

- superoxide dismutase (SOD) catalyzes the process of disproportionation of two superoxide radicals with the formation of hydrogen peroxide and molecular oxygen in the cytoplasm, mitochondria and nucleus: $2O_2^{\bullet -} + 2H^+ \rightarrow H_2O_2 + O_2$.

As stated above, as a result of lipid peroxidation, damage to cell membranes occurs, which affects their properties and cell functioning.

The main changes include:

• changes in the properties of the lipid layer;

• an increase in the microviscosity of membranes;

• changes in the surface charge of membranes and lipoproteins;

• decrease in hydrophobic volume;

• an increase in the polarity of the lipid phase;

• increased permeability to hydrogen ions;

• increased permeability to calcium ions.

Thus, lipid peroxidation plays an important role in the process of apoptosis (a regulated process of programmed cell death, as a result of which the cell breaks down into separate apoptotic bodies limited by the plasma membrane), regulation of membrane structure and their functions (presentation of receptors, work of ion channels, release of biologically active substances, signal transmission between cells, etc.).

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