Changes in taste sensation of sour, salty, sweet, bitter, umami, and spicy, as well as levels of malondialdehyde serum in radiographers

by Agniz Nur Aulia

Research Report

Changes in taste sensation of sour, salty, sweet, bitter, umami, and spicy, as well as levels of malondialdehyde serum in radiographers

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ABSTRACT

Background: *Radiation used for any purpose certainly contains potential danger to humans. Radiographers are given a task, authority, and responsibility by the competent authority to conduct radiography and imaging in Health Services Unit. Some researches on the effects of radiation on cancer patients show that radiation can cause an increase in bitterness and metal taste [in cancer patients] leading to discomfort in the oral cavity. In body, free radicals then can cause lipid peroxidation process. Lipid peroxidation is an oxidative destruction of Polyunsaturated Fatty Acid producing malondialdehyde (MDA).* ***Purpose:*** *This research aimed to determine the effects of radiation on changes in the taste sensation of sour, salty, sweet, bitter, umami, and spicy as well as levels of MDA serum in radiographers.* ***Method:*** *This research was an observational laboratory research using post- test control design. Samples were selected using simple random sampling technique. The samples were seven radiographers who had been working for five years in the laboratory and radiographic units in Surabaya.* ***Result:*** *Based on the results of statistical tests, it showed that there was no differences in the sensitivity of all tastes between the groups tested. Moreover, the results also depicted considerable value for the sour taste of 0.550, the saltiness of 0.775, the sweetness of 0.294, the bitter taste of 0.065, the umami taste of 0.705, and the spicy taste of 0.319 (p>0.05). However, the dramatic increase was higligted in levels of MDA serum with a significant value of 0.065 (p>0.005).* ***Conclusion.*** *There were no changes in the sensitivity of sour, salty, sweet, bitter, umami, and spicy tastes, but there was a significant increased in level of MDA serum in the radiographers compared to the control group.*

Keywords: *radiographers; taste buds; MDA serum level*

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INTRODUCTION

There are some senses of taste in the oral cavity, namely salty, sour, sweet, bitter, and umami tastes. The emergence of a sense of bitter taste is due to the bonding between chemicals as bitter taste stimulants in receptors. This reaction results in G-protein release unit α, which is the sensory receptors of bitter taste referred to as gustducin. Gustducin then activates the enzyme, in these circumstances causing closure of channel K^+ then stimulating phospholipase C (PLC) to activate phosphatidylinositol phosphate (PIP) into inositol triphosphate (IP3). Next, inositol triphosphate makes Ca^{2+} released from the endoplasmic reticulum, causing depolarization. Consequently, increasing concentrations of Ca^{2+} in the receptor cells of bitter taste causes an increase in the sense of bitter taste then forwarded to the memory inside the brain.[1]

Taste buds on the tongue contain pores, known as taste pores containing microvilli that carry gustatori cells that will be stimulated by various chemical liquids. Microvilli are surface receptors for taste. Sensory nerve fibers from the taste buds on the anterior part of the tongue then will deliver impulses to the brain stem through chorda tympani (branch of the facial nerve). The posterior part of the tongue, on the other hand, will deliver impulses to the brain stem through glossopharyngeal nerve, while the taste buds in the pharynx and epiglottis innervated by the vagus nerve to interpret the taste.[1]

Utilization of radiology in various fields, especially in the health field can be used for both diagnosis and treatment of patients. Radiation used for any purpose, nevertheless, will certainly contain potential danger to humans. Radiation safety, as a result, is an effort made to create conditions in which dose of ionizing radiation on humans and environment does not exceed a specified limit. Harmful effects of ionizing radiation are known as somatic effects when suffered by people exposed to radiation, and called as genetic effects when experienced by their offsprings.[2]

The basic unit of biological tissue is cell. If the ionizing radiation penetrates the tissue, it may result in ionization and produce free radicals, such as hydroxyl free radical (OH •), which consists of oxygen atoms and hydrogen atoms. In chemistry, free radicals are highly reactive and can alter important molecules in the cell. Radiation can ionize molecules of DNA directly causing chemical changes in DNA and if the DNA interacts with the hydroxyl free radical will cause adverse biological effects, such as cancer or abnormal genetics.[3]

In the body, moreover, free radicals can trigger lipid peroxidation process. Lipid peroxidation exposed to oxygen then is responsible for the destruction of body tissue in vivo, causing various diseases, such as cancer, atherosclerosis, aging, and others. Lipid peroxidation is a chain reaction with various damaging effects.[4]

Lipid peroxidation is an oxidative destruction of polyunsaturated fatty acids, which have a long-chain producing malondialdehyde (MDA) compound. Malondialdehyde is also a component of cell metabolites produced by free radicals. Therefore, a high concentration of MDA serum indicates oxidation process in the cell membrane. MDA can be used as an index measuring the activity of free radicals in the body. High levels of MDA in the body can be caused by increased activity of free radicals.[5]

For those reasons, this research aimed to analyze how the senses of taste of radiographers almost daily exposed to radiation even in small doses, but continually in the long term was. Specifically, this research focused on the effects of radiation on changes in radiographers' sensation of sour, salty, sweet, bitter, umami, and spicy tastes as well as in their MDA serum levels.

MATERIALS AND METHOD

This research is an observational laboratory research using post test control study design. This research was conducted by performing a test on taste sensitivity and MDA serum levels in samples that had been exposed to radiation. Samples in this research were radiographers at the Radiology Units of Universitas Airlangga Hospital, Surabaya Surgical Hospital, and the Clinical Laboratory of Mitra Husada Surabaya Hospital. Criteria for the samples of radiographers classified into the treatment group in this research were as follow: a) working in medical radiography for 5 years or more; b) men aged between 18-44 years (WHO); c) no history of systemic disease; d) do not smoke; e) no impairment/sores in the oral cavity.

Meanwhile, criteria for the samples of non-radigraphers classified into the control group were as follow: a) men aged between 18-44 years (WHO); b) no history of systemic disease; c) do not smoke; d) no impairment/sores in the oral cavity.

This research, moreover, focused on taste sensitivity and MDA serum levels. This research was conducted at the Laboratory of Biochemistry, Faculty of Medicine, Universitas Airlangga from August to November 2015. The number of samples then was determined using Lemeshow's formula. As a result, the total of samples in this research was seven people.

A sensitivity test was perforemed on each sample of the treatment group and the control group by appliying citric acid solution with a concentration of 0.0044 M, 0.0057 M, 0.007 M, 0.0096 M, 0.0125 M, 0.0162 M, 0.0211 M, and 0.0275 M on the taste buds of sour taste located in the lateral part of their tongue.[6] NaCl solution with a concentration of 0.003 M, 0.01 M, 0.0013 M, 0.0017 M, and 0.022 M also was applied on the taste buds of salty taste located in the lateral part of their tongue.[7] Sucrose solution with a concentration of 0.01 M, 0.013 M, 0.017 M, 0.022 M, 0.029 M, 0.038 M, 0.049 M, and 0.064 M was applied on the taste buds of sweet taste located in the anterior part of their tongue.[8] In addition, quinine solution with a concentration of 0.031%, 0.063%, 0.125%, 0.25%, 0.5%, 1%, and 2% also was applied on the taste buds of bitter taste located in the posterior part of their tongue.[6] L-glutamate solution with a concentration of 1%, 2%, 3%, 4%, 5%, and 6% then was applied on the taste buds of umami taste located in the center of their tongue.[6] And, capsaisin solution with a concentration of 3.13%, 6.25%, 12.5%, 25%, 50%, and 100% also was applied on the taste buds of spicy taste located in the anterior part of their tongue.[6]

Furthermore, a test was carried out on MDA serum levels by taking blood from their sample and then centrifuging them to obtain serum. The test was conducted in the laboratory. Next, MDA serum levels were measured with thiobarbituric acid (TBA) reagent through nucleophilic addition reactions to form MDA-TBA compounds. 1,1,3,3-tetraetoksipropana or malondialdehyde tetrebutylammonium salt compound then was used to make standard curve since 1,1,3,3-tetraetoksipropana can be oxidized in acidic aldehyde compound that can react with TBA. Although this method is not specific, but this method is accepted as a marker of lipid peroxidation for many researchers.[16]

RESULTS

This research was conducted using two research groups, namely control group consisted of non-radiographers and the treatment group consisted of radiographers. The sensitivity test was performed on each group including taste buds for sour, salty, sweet, bitter, umami, and spicy tastes. Malondialdehyde serum levels also were measured by taking blood samples from each group. The total of samples in this research was seven samples as based on a minimum sample of Lameshow's formula. The results of the sensitivity test in each group can be seen in Figure 1, while the measurement results of their MDA serum levels can be seen in Figure 2 as attached in the appendix.

The data of obtained from the results of the sensitivity test on each group then were tested using Mann Whitney test. Mann Whitney test was performed to determine the significance of difference between the two groups of samples. The results of Mann Whitney test showed that there was no significant difference between the two groups. The significant value for the bitter taste sensitivity was 0065, while for the umami taste sensitivity was 0.705. The significant value for the sweet taste sensitivity was 0.294, while the salty taste sensitivity was 0.775. And, the significant value for the sour taste sensitivity was 0.550, while for the spicy taste sensitivity was 0.319 ($p>0.05$). Therefore, it means that there was no significant difference in taste sensitivity between the two groups.

In the control group consisted of non-radiographers, furthermore, the average levels of MDA serum in the control group was 2.619 nmol/ml. On the other hand, in the treatment group consisted of radiographers the average levels of MDA serum was 11.525 nmol/ml. The data about the levels of MDA serum then was tested using independent t test. Independent test t test was conducted to determine the significance of difference between the two groups. Before conducting the test, however, there was a requirement to test the data for their normally distribution. Thus, Kolmogorov-Smirnov statistic test was performed. The results of the Kolmogorov-Smirnov test showed the significance value of those two groups was more than 0.005 ($p>0.005$). It indicates that the data obtained in those two groups were normally distributed.

Therfore, the independent t test then was performed. The results of the independent t test showed the significance value of those two groups was 0.065 ($p>0.005$). It means that there were significant differences in MDA serum levels between the two groups.

DISCUSSION

In humans, the senses of taste are very significant since with the senses of taste they can taste scrumptious and delicious food and drink. The sensation of taste arises from the chemicals binding to the receptor senses of taste (taste buds) mostly located on the surface of the tongue and soft palate. However, only the chemical in solution or solids that have been dissolved in saliva can bind to receptor cells.[8]

After each research group was tested for their sensitivity of flavors, including senses of bitter, umami, sweet, salty, sour, and spicy tastes, it is known that there was no significant difference, either decrease or increase, in the sensitivity of taste between those two groups. This is possible because the radiation exposure received by the radiographers was with very small doses, exposure time was not long enough, and the use of radiation protection was good so that the biological effects including changes in taste sensitivity had not happened yet. Factors known to influence the onset of biological effects from exposure to the outside are absorbed dose, exposure distribution in the body, distribution of exposure time and age.[9]

In the sense of bitter taste, there was no increase in this sensation. This sense of bitter taste actually can arise because of a bond between the solutions of quinine as stimulants for bitter taste receptors. This reaction makes G-protein in the plasma membrane release α unit, which in sensory receptors of bitter taste is referred to Gustducin. Gustducin activates phospholipase enzyme, as a result, in these circumstances K^+ channels are locked, then stimulating phospolipase C (PLC) to activate phospatidylinositol 4,5-biphosphate (PIP2) into inositol triphosphate (IP3) and diacylglycerol (DAG). Next, inositol triphosphate makes Ca^{2+} released from the endoplasmic reticulum causing depolarization and then neurotransmitters, such as serotonin released that generates sensitive post-synaptic axon ATP innervating senses of taste and connecting organs and peripheral sensory neurons in the back of the brain triggering a bitter taste that can be tasted.[6]

In the sense of sour taste, moreover, there was no decrease in this sensation of the radiographers. This is most likely due to the presence of acid (citric acid solution), which makes excitation applied on sour taste receptors in tongue and then arises a bond of H^+ ions leading to the closure of K^+ channels. The closing of K^+ channel stimulates membrane depolarization and generates action potentials. The hydrogen ions then will trigger the sensation of sour taste.[10]

Similarly, in the sense of salty taste, there also was no decrease in this sensation of the radiographers. It is probably because when NaCl is applied on the tongue, it can trigger depolarization of the salty taste receptor cells through Na^+ channels similar to channels of sodium in epithelial cells (ephitelial-type Na^+ channels [ENaC]). Ephitelial-type Na + channels are specific sodium receptors involved in tasting salty taste. Because of NaCl solution in sufficient concentration, the achievement of threshold can occur so that salty taste can be felt.[10]

Like in salty tatse, in sweet taste there also was no decrease in this sensitivity of taste. It's likely caused when sucrose solution is applied on the tongue, the substance of sweet taste is then bound to Gprotein-Coupled Receptors (GPCRs) that binds to Gprotein gustducin found on the cell surface. Gprotein complex is named gustducin because of the similarity of structure and action to transducin. Next, this gprotein complex activates adenylyl cyclase as the second messenger to trigger Adenosine triphosphate (ATP) turning into cyclic adenosine 3'5'-Monophosphate (cAMP) which then activates phosphokinase A until an ion channel phosphorylation occurs. K ion channel then will be closed, and depolarization occurs so that neurotransmitters are released and the stimulation of sensory neurons occurs, so sweet taste can be felt.[11]

In addition, in the sense of umami taste, there also was no decrease in this sensitivity of taste. This is possible because at the moment there is a solution of L-glutamate on the tongue. This substance is soluble in saliva and then can diffuse into pore taste through fluid layer to create a relationship with both receptor membrane on microvilli and apical membrane. Mechanism of the substance reacting with taste villi starts receptor potential by binding chemicals to receptor molecules of umami taste, such as (metabotropic glutamate receptors 4 [mGluR4], metabotropic glutamate receptors 1 [mGluR1]), and dimer receptor (Taste 1 Receptor 1 [T1R1] + Taste 1 Receptor 3 [T1R3]) undergoing intracellular reaction and causing excitation of primary sensory afferents facilitating change of PIP2 into IP3 and diacylglycerol. Next, inositol triphosphate increases the activity of intracellular calcium and the release of calcium into cytoplasm. The release of intracellular calcium then stimulates the release of neurotransmitters which in turn causes sensitive post-synaptic axon ATP innervates senses of taste and connects organs and peripheral sensory neurons behind the brain.[6]

Simiarly, in the sense of spicy taste there also was no decrease in this sensitivity of taste since capsaisin solution applied on the tongue will be perceived by taste buds contained in papillae of the tongue by vanilloid receptor 1 (VR-1) or Taste Receptor Potential Vanilloid 12 (TRPV-12), as a component of a molecule mediating the flow of hot-activated in nociceptors C, thus modulating the activity of cacade second meszinker in taste receptor cells

(TRCs). Free nerve ending receptors on the taste buds are served by chorda tympani nerve and send spicy taste to the brain so that the brain will receive and interpret it as pain.[6]

In the normal mechanisms of stimulation to the senses of taste buds in radiographers, there are actually no distractions, so there are no changes in sensation of sour, salty, sweet, bitter, umami, and spicy. In addition, the taste bud cells also experience a change in growth, death, and regeneration. The taste bud cells are continuously replaced through mitotic division process of cells around, so some of them are young cells and more mature cells located towards the middle of the senses of taste and will soon break down and dissolve. The system is not only influenced by the taste buds cells, but also taste receptor cells and taste nerves.[9)] [8] The ability to taste in a person is also influenced by several things, including individual factors, threshold value, and concentration.[12] It also can affect whether there is any change in the perceived sensitivity of taste on the tongue.

Based on the research results obtained, there was a significant difference in MDA serum levels between the group of radiographers and the control group consisted of non-radiographers. The levels of MDA serum in the group of radiographers were higher than in the control group consisted of non-radiographer since the blood sample taken has a high radiosensitivity and are considered as the cells that are sensitive to biological effects derived from radiation exposure.[15] In addition, most of the human body is composed of water. Radiation interacts with atoms or other molecules in the cells (especially water), which then will produce free radicals. In the body, free radicals can cause lipid peroxidation process. In chemistry, free radicals are highly reactive and can alter important molecules in the cells.[5]

Free radicals can also initiate lipid peroxidation directly against polyunsaturated fatty acid on the cell wall. Free radicals will cause lipid peroxidation of cell membranes and produce malondialdehyde (MDA) compounds. Lipid peroxides will be formed in the chain that is longer and can damage the cell membrane organization.[5] Since the radiation exposure received by the radiograhers was more often than the control group consisted of non-radiograhers, the MDA serum levels in the group of radiograhers were higher.

The high MDA level may indicate the high level of free radicals in the body. The high level of free radicals in the body is very dangerous since it can cause damage to the cells by direct ionizing of DNA molecules, causing chemical changes in the DNA. The chemical changes in DNA occur indirectly if the DNA interacts with the hydroxyl free radicals.

Consequently, this condition then can cause adverse biological effects, such as damage to the cells of the taste buds and damage to acinar cells in salivary gland triggering discomfort in the oral cavity.[13] The damage to cells of the taste buds may result in a decrease in sensitivity to sour, salty, sweet, umami, and spicy tastes.

In addition, the radiation also can cause damage to acinar cells in salivary gland. Those cells are very sensitive to radiation. The main effect of radiation on the salivary gland is xerostomia characterized by a decrease in the volume of saliva. The decline in the volume of saliva will cause disruption in distributing stimuli / impulses of the senses to the brain.[2]

Therefore, the low radiation dose is still risky since changes to the biological system, both molecular and cellular, eventually will develop and lead to a severe effect on health, such as malignancy. Thus, the radiation exposure with low dose on a tissue even can increase the risk of cancer, which statistically can still be detectable at a population, but not necessarily associated with individual exposures. In this research, though there was no impairment of sensitivity of sensory taste, there was a significant increase in MDA serum levels. This is because blood cells are more sensitive to radiation than the cells of taste buds. In addition, the biological changes in the body also can be affected by the absorbed dose, exposure distribution in the body, as well as the distribution of exposure time and age.[9] Thus, the use of precise radiation dose and the right application of radiation protection are good for radiographers and also necessary to avoid the negative long term biological effects.

Based on the results and discussion of this research, it can be concluded that there was no increase or reduction in the sensitivity of bitter, sour, sweet, salty, umami, and spicy tastes, but there was an increase in MDA serum levels in the group of radiographers compared to the control group.

From the conclusion above, there are some suggestions that are expected to be carried out as follow a) further research should be focused on the sensitivity of taste sense with a longer duration of radiation exposure to radiographers; b) further research should be noted on whether radiation protection is good and right in order to avoid undesirable long-term radiation effects.

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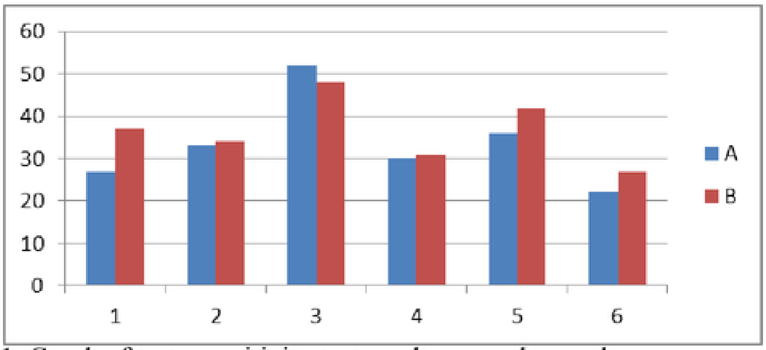

Figure 1. Graph of taste sensitivity test results on each sample

The graph above shows the total score obtained from the amount of concentration that can be perceived by the samples. X-axis is the sense of taste, namely:

"1" sense of bitter taste "4" sense of salty taste
"2" sense of umami taste "5" sense of sour taste
"3" sense of sweet taste "6" sense of spicy taste

Meanwhile, the Y-axis is the total score, the group "A" is the control group control group and "B" is the sample group of radiographers.

"1" sense of bitter taste "4" sense of salty taste
"2" sense of umami taste "5" sense of sour taste
"3" sense of sweet taste "6" sense of spicy taste

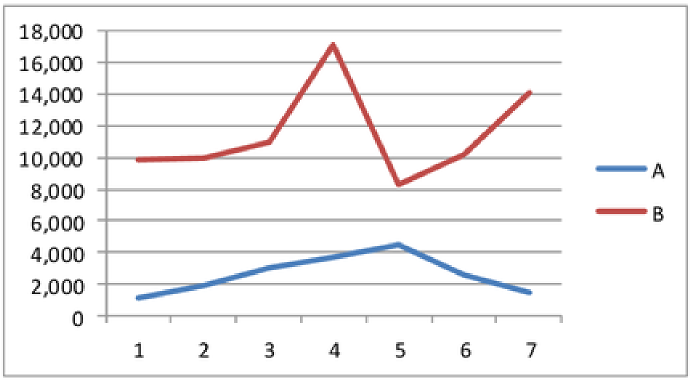

Figure 2. Curve of MDA serum levels in the control group and in the sample group of radiographers.

The curve above shows the results of the absorbance measurements of MDA serum level in the research groups. The X-axis is the serum levels of MDA (nmol / ml), Y-axis is the research groups, namely "A" is the control group and "B" is the sample group of radiographers.

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