

Biophysical effects of continuous X-ray on the level of serum thyroxin in hyperthyroidism patients

Samira Hassan Abdulah
Technical Institute /Kirkuk
Semire2010@yahoo.com

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Abstract

The thyroid hormones, thyroxin (T_4) and triiodothyronine (T_3), are tyrosine-based hormones produced by the thyroid gland primarily responsible for regulation of metabolism. An important component in the synthesis of thyroid hormones is iodine. The major form of thyroid hormone in the blood is thyroxin (T_4), which has a longer half-life than T_3 . The ratio of T_4 to T_3 released into the blood is roughly (20 to 1). The level of thyroxin is affected by radiation. The aim of the study to determine and to assess the effects of continuous X-rays on thyroxin level in vitro quantitative measures. Thirty patients with hyperthyroidism disease were enrolled in this study. Blood samples were tested and irradiated by x-ray radiation source of total dose rate (0.4).Gry/sec. The level of thyroxin were determined before and after irradiation. The results showed that the level of thyroxine are significantly reduced ($P<0.01$) after x-ray irradiation.

It is concluded that x-ray ionizing radiation, reduced thyroxin level by free radical forming and protein damaging.

Key word: Thyroxin, x-ray ,free radical .

التأثيرات الفيزيائية البايولوجية للأشعة السينية المستمرة على مستوى الثايروكسين عند المصابين بفرط إفراز هرمون الثايروكسين

سميرة حسن عبدالله
معهد التقني - كركوك

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الخلاصة

تفرز الغدة الدرقية هرمون الثايرويد والذي يكون على نوعين ثايروكسين و ثالث يود الثيرونين والمصنوع بشكل اساسي من اليود، وهو المسؤول عن تنظيم الايض الغذائي في الجسم. ثايروكسين يمثل معظم هرمون الثايرويد المنفرز في الدم والذي نصفه العمري اطول من ثالث يود الثيرونين حيث تكون نسبة الثايروكسين الى نسبة ثالث يود الثيرونين ٢٠ / ١. يتأثر مستوى هرمون الثايروكسين بالاشعاع، ان الهدف من هذه الدراسة هو تحديد وتقييم تأثير الاشعة السينية المستمرة على مستوى هرمون الثايروكسين بقياس كمي خارج الجسم. تم إخضاع (٣٠) نموذج من دم للأشخاص المصابين بفرط إفراز هرمون الثايروكسين. حيث تم اختبار نسبة الثايروكسين للنماذج ومن ثم شععت بالاشعة السينية المستمرة بمعدل الجرعة ٤،٤ كري /ثا. تم اختبار النماذج لمعرفة مدى تأثير الثايروكسين بالأشعة السينية المستمرة. أظهرت النتائج بأن مستوى هرمون الثايروكسين تنخفض بشكل واضح (الاحتمالية اقل من ٠،٠١) بعد التشعيع بالأشعة السينية المستمرة عند كل تغيير في زمن التعرض أو الجرعة. نستنتج من هذه الدراسة ان الاشعة السينية يقلل من مستوى هرمون الثايروكسين بتكوين جذور حرة وتحطيم البروتين.

كلمات الدالة: Thyroxin ,x-ray ,free radical

Introduction

1- Thyroid hormone:

The thyroid hormones, thyroxin (**T₄**) and triiodothyronine (**T₃**), are tyrosine-based hormones produced by the thyroid gland primarily responsible for regulation of metabolism. An important component in the synthesis of thyroid hormones is iodine. The major form of thyroid hormone in the blood is thyroxin (**T₄**), which has a longer half-life than **T₃**. The ratio of **T₄** to **T₃** released into the blood is roughly 20 to 1 [1]. Thyroxin is converted to the active **T₃** (three to four times more potent than **T₄**) within cells by deiodinases (5'-iodinase). These are further processed by decarboxylation and deiodination to produce iodothyronamine (**T_{1a}**) and thyronamine (**T_{0a}**) [2].

2- Production of the thyroid hormones:

Thyroid hormones (**T₄** and **T₃**) are produced by the follicular cells of the thyroid gland and are regulated by TSH made by the thyrotrophs of the anterior pituitary gland. Because the effects of **T₄** in vivo are mediated via **T₃** (**T₄** is converted to **T₃** in target tissues), **T₃** is 3- to 5- fold more active than **T₄**. Thyroxin (3, 5, 3', 5'-tetraiodothyronine) is produced by follicular cells of the thyroid gland. It is produced as the precursor thyroglobulin (this is not the same as TBG), which is cleaved by enzymes to produce active **T₄**. Thyroxin is produced by attaching iodine atoms to the ring structures of tyrosine molecules. Thyroxine (**T₄**) contains four iodine atoms. Triiodothyronine (**T₃**) is identical to **T₄**, but it has one less iodine atom per molecule [3]. Iodide is actively absorbed from the bloodstream by a process called iodide trapping. In this process, sodium is cotransported with iodide from the basolateral of the membrane into the cell and then concentrated in the thyroid side follicles to about thirty times its concentration in the blood. Via a reaction with the enzyme thyroperoxidase, iodine is bound to tyrosine Residues in thyroglobulin molecule, forming monoiodotyrosine (MIT) and diiodo- tyrosine (DIT).

Linking two moieties of DIT produces thyroxin combining one particle of MIT and one particle of DIT produces triiodothyronine. [4]

$DIT + MIT \rightarrow r-T_3$ (biologically inactive)

MIT + DIT → triiodothyronine (referred to as T₃)
DIT + DIT → thyroxin (referred to as T₄)

Proteases digest iodinated thyroglobulin, releasing the hormones T₄ and T₃, the biologically active agents central to metabolic regulation. Thyroxine is believed to be a prohormone and a reservoir for the most active and main thyroid hormone T₃. T₄ is converted as required in the tissues by iodothyronine deiodinase. Deficiency of deiodinase can mimic an iodine deficiency. T₃ is more active than T₄ and is the final form of the hormone, though it is present in less quantity than T₄ [5].

3-Related disease:

Excess of thyroxin can cause (Hyperthyroidism) is the clinical disease caused by an excess of circulating free thyroxin, free triiodothyronine, or both. Thyrotoxicosis is often used interchangeably with hyperthyroidism, but there are subtle differences. Although thyrotoxicosis also refers to an increase in circulating thyroid hormones, it can be caused by the intake of thyroxin tablets or by an over-active thyroid, whereas hyperthyroidism refers solely to an over-active thyroid [6].

4- Radiation:

The history of radiation begins with the discover of x-ray by wilhelm Roentgen in November 1895. The human being are exposed throughout their life to ionizing radiation this radiation comes from :

1-Natural source 2-Cosmic rays 3-Man-made source.

X-rays are electromagnetic radiation that is capable to causing ionization in matter due to its high energy content, it can penetrate the body to allow non invasive visualization of the internal anatomy and can cause damage in tissues of the body [7].

5- Biological effects of radiation :

Ionizing radiation imparted to living systems can result in an array of biological endpoints including tissue injury, carcinogenesis and death. The initial step in this interaction of radiation with biological material is the deposition of energy to atoms and molecules which results in ionization and excitation [8]. Small quantity of energy from radiation exposure results from the non uniform deposition of energy and through biochemical processes that amplify damage [9].

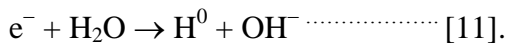
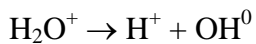
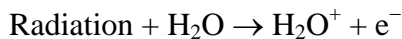
Action of ionizing radiation on cells is two types:

- 1- Direct action.
- 2-Indirect action

1-Direct actions : was occurred within milliseconds following irradiation , this type of action causes a number of physical and chemical events is used to describe the death of the cell [10] .

2-Indirect action: Since water is a major constituent of all biologic materials, water composes 80 % of the mass of biological systems; irradiation of water produces reactive chemical species that can damage biological molecules. These damage products may in turn initiate chemically reactive chain processes, with other biological molecules propagating further damage.

When the cell is exposed to ionizing radiation, several responses may occur ranging from no detectable damage to cell death.



Detrimental effects from low level radiation exposure and from chronic exposures may also manifest themselves long after the initial event. These effects can be divided into three areas of concern

1. Somatic
2. Genetic
3. Utero effects. [12] .

The aim of the study:

To determine and to assess the effects of continuous X-rays on thyroxin level in vitro quantitative measures.

Material and Methods

The study was carried on 30 patients with hyperthyroidism who attended Kirkuk General Hospital in Kirkuk city, for period from 1-09-2011 to 01-12-2011.

Thyroxin level determination:

Each sample tested by TosoH analyzer instrument to know thyroxin level before and after irradiation .The normal range of T4 (4.9-11.0 µg /dl).

X-ray dose calculation:

The exposure can be calculated by the following equation:

$$\frac{\text{Absorbed dose of substance}}{\text{Absorbed dose of air}} = \frac{E \text{ (Ma/p)}}{E \text{ (Ma/p) air}}$$

Where E is the mean photon energy (X-ray).

(M a/p) sub = mass energy – absorption coefficient for substance.

(M a/p) sub = mass energy – absorption coefficient for air.

$$\text{Absorbed dose of substance} = \frac{0.869R \text{ (Ma/p) sub}}{(M a / p) \text{ air}} \dots \text{Rads}$$

$$= fR \dots \text{Rads}$$

$$0.869R \text{ (Ma/p) sub}$$

Where $f = \frac{0.869R \text{ (Ma/p) sub}}{(M a / p) \text{ air}}$ is the factor for converging

Roentgen in to rad.

1 Gy = 100 Rad

Method of sample irradiation:

X-ray irradiation:

1.30ml of serum at known thyroxin level (µg /dl) put in container where surface area is 4.9cm². The container put under the radiation source at distance 20cm in limited flied size of 2x2cm. The samples are irradiated at total doses of X-ray between (0.02-0.136Gy) and the exposure time between (0.40-2.75 sec).

Result & Discussion

A total number of 30 patients serum with hyperthyroidism disease irradiated by the X-ray radiation..The level of T4 in blood samples were studied before and after irradiation.

1: Thyroxin (T4) level measurement:

The change in the level of thyroxin is clearly appeared after irradiation by X-ray. The level of thyroxin was significantly lowered ($P < 0.01$) after irradiation (table 1) in comparison with its level before irradiation. This reduction in the level of thyroxin is directly

Proportional with the exposure time or X-ray dose at constant dose rate .These results are appear in figure (1).

Table (1): The relation between X-ray radiation dose and the level of serum thyroxin (T4) before and after irradiation. .(at constant dose rate)

Samples number	thyroxin level before X-ray irradiation (mg/dl)	Exposure time (sec)	Dose of X-ray (Gy)	Thyroxin level after x-ray irradiation (µg/dl)
1	21.53	0.40	0.02	22
2	19.44	0.48	0.024	19.19
3	18.32	0.58	0.028	17.72
4	22.11	0.64	0.032	16.45
5	20.22	0.72	0.036	19.17
6	19.33	0.80	0.04	15.74
7	20.62	0.97	0.044	16.47
8	22.15	1.05	0.048	18.42
9	22.77	1.13	0.052	14.9
10	21.22	1.2	0.056	15.89
11	18.55	1.21	0.06	13.23
12	21.12	1.23	0.64	14.01
13	20.14	1.37	0.068	15.08
14	19.65	1.45	0.072	11.96
15	20.28	1.53	0.076	11.81
16	22.24	1.61	0.08	10.67
17	22.78	1.7	0.084	10.01
18	19.51	1.78	0.088	9.5
19	22.50	1.86	0.092	12.72
20	21.72	1.94	0.096	9.89
21	21.11	2.02	0.1	9.28
22	20.51	2.024	0.104	9.21
23	20.33	2.17	0.108	6.7
24	21.42	2.26	0.112	7.22
25	20.55	2.34	0.116	5.76
26	20.56	2.42	0.12	7.18
27	20.66	2.50	0.124	4.61
28	21.74	2.59	0.128	5.2
29	21.53	2.67	0.132	4.39

30	20.44	2.75	0.136	3.3
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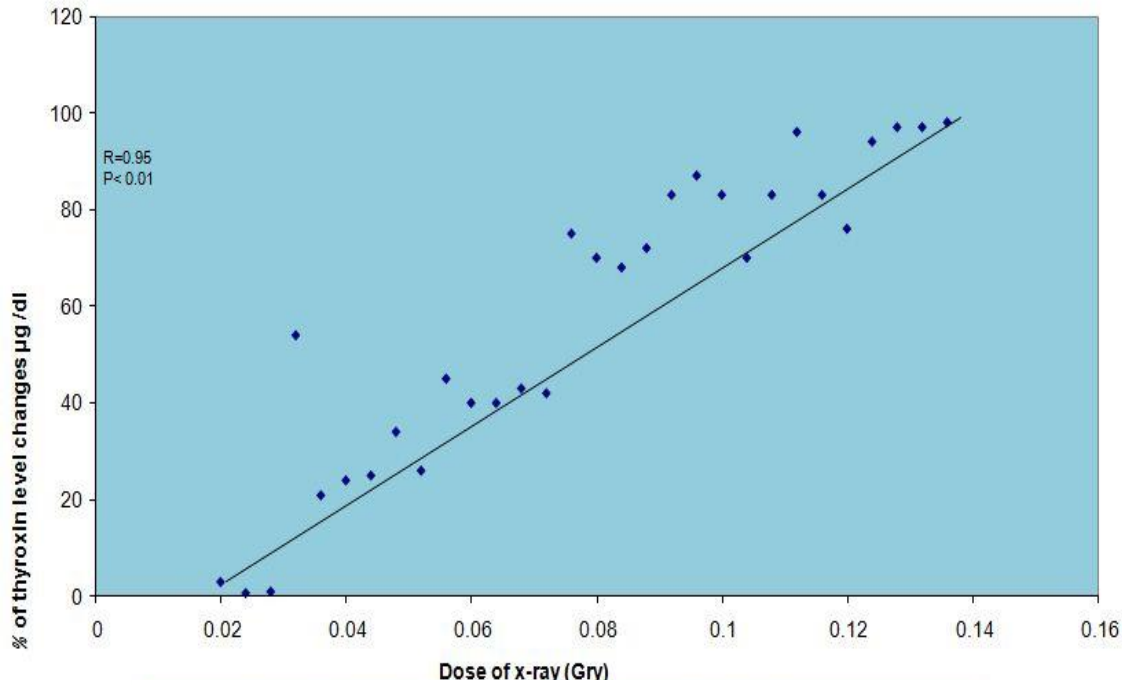


Fig.(1): The Relation Between Percentage Of Thyroxin Level Changes And The Does Of X-Ray

2-Thyroxin level measurement before and after X-ray irradiation (for the same serum):

Serum has been divided in to five parts and every parts exposed to X-ray radiation at different exposure time . The measurements have been repeated three time and the mean is taken .The level of thyroxin before irradiation are shown in (table 2) which is significantly different from after irradiation $P<0.01$).The level of thyroxin is gradually reduced when exposed to X-ray radiation .This reduction is clearly appeared in this work and increased with increasing in the exposure time or X-ray dose at constant dose rate (fig 2).

Table (2): The relation between X-ray radiation dose and the level of serum thyroxin Before and after irradiation (at constant dose rate)

Samples number	Exposure time (sec)	Dose of x-ray (Gy)	Thyroxin level (µg /dl)
before x-ray	0	0	22

irradiation			
After x-ray irradiation			
1	0.40	0.02	21.4
2	0.72	0.036	19.04
3	1.21	0.06	16.4
4	1.7	0.084	13.4

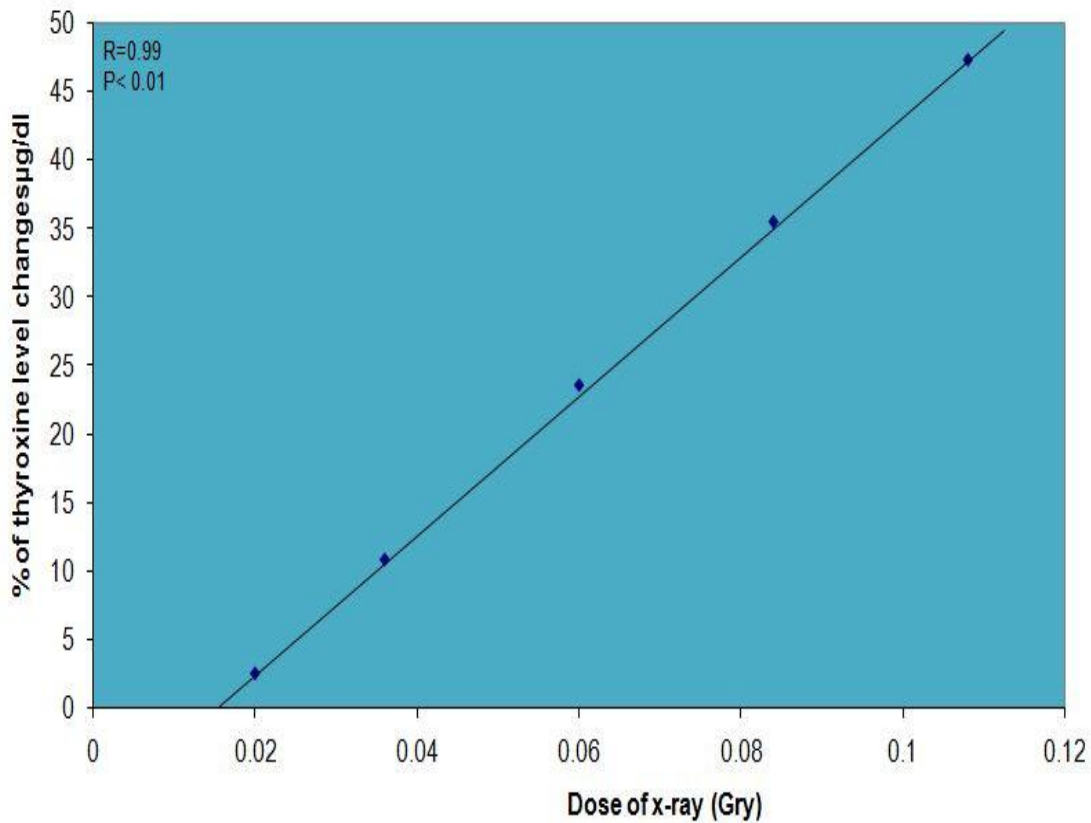


Figure (2): The relation between the percentage of thyroxine level changes and the does X-ray

Discussion

This study was aimed to assess the effects of X-ray radiation on thyroxine level and to find the most important factor in this radiation of changes in the thyroxine level.

In the present study the level of thyroxine is significantly reduced after irradiation when compared with the level before irradiation ($P<0.01$). The level of thyroxine was gradually reduced at each

increase in exposure time or exposure energy (fig 1) (fig 2) .Our result were in agreement with [13].

The reduction in the level of thyroxin may be due to:

1- Free radical is formed by radiation, Free radicals may react with molecules of oxygen and such reactions are great radiobiological importance because they may lead to the production of peroxide radicals which causes biological damage,[14,15] .

2-Protein damaging:

Thyroxine molecules are non soluble in water ,it needs bound to transport protein for Circulating In blood Thyroxin Binding Pre albumin, Thyroxin binding globulin).

Thyroxin is derivative of amino acid. The x-ray causes damage in protein by change in solubility and destruction in amino acid [16].

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