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Original Article

Relationship between body mass index and external exposure in hyperthyroid patients treated with iodine-131

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Abstract: We performed this study to evaluate the correlation between Body Mass Index (BMI) and Exposure Rate (ER) of hyperthyroid patients treated with iodine-131 so that in case of any relationship, we can improve the prescribed dose for the treatment of hyperthyroid patients and its side effects on the body and the environment. In this analytical and cross-sectional study, 30 patients with hyperthyroidism treated with liquid iodine-131 were randomly selected. We recorded demographic indicators (age, height, and weight) and ER. Patients were treated with the activity of 8-29 mCi (mean 14.4 mCi) oral I-131. The external radiation of patients was measured from a distance of one meter parallel to the patient's thyroid gland at intervals of 6 to 24 hours post-iodine-131 administration. ER measurements and other acquired data were statistically analyzed by R software and its methods. Data were normalized using the Shapiro method, and due to the non-normality of the data in the correlation test, the Spearman method was used. The measurements of this study represent two main findings: 1. There is a significant relationship between ER and iodine-131 activity because the observed significance level (*P*-value =0.002) is smaller than the predicted error value (0.01). 2. There is no significant relationship between ER and BMI because the observed significance level (*P*-value =0.082) is greater than the predicted error value (0.05). The present study's findings show a negative relationship between BMI and ER. Still, since the *P*-value is more than 0.05, this relationship is not statistically significant.

Keywords: Hyperthyroidism, exposure, iodine-131, body mass index, radiation

Introduction

Hyperthyroidism, known clinically as thyrotoxicosis, is caused by an increase in thyroid hormone secretion and can cause adverse disorders in the body [1]. Hyperthyroidism is a metabolic condition characterized by the rise in the levels of the thyroxine hormones (T4), triiodothyronine (T3), or both in the thyroid gland or a decrease of thyrotropin hormone - thyroid-stimulating hormone (TSH) - secreted by the pituitary gland and controls T3 and T4 secretion from thyroid follicles [2].

The most common causes of overproduction of thyroid hormones include graves' disease, toxic multinodular goiter, and toxic adenoma [3, 4]. Graves' disease, the most common cause of hyperthyroidism, is an autoimmune disorder in which thyroid-stimulating antibodies activate hormone receptors, causing excess and out-of-control amounts of thyroid hormones [5].

Hyperthyroidism is a relatively common disease and occurs in women about four to eight times more than in men [6, 7]. In the United States, about 12 out of 1000 people have an overactive thyroid. The prevalence of complete, overt, and subclinical hyperthyroidism in the general population of Iran is 2.43%, 0.69%, and 1.52%, respectively. Also, the annual incidence of complete, overt, and subclinical hyperthyroidism is estimated at 2.2, 0.8, and 1.3 per 1000 Iranians, respectively [3, 8].

This disease is diagnosed by physical examination, laboratory analysis of blood samples, or patient history. Treatment choice depends on the underlying diagnosis, the advantages over the risks in a particular clinical condition, and the patient's preference. The severity of hyperthyroidism and limitations such as pregnancy and breastfeeding also affect the choice of appropriate treatment [9-11].

Due to the overproduction of thyroid hormones, hyperthyroidism can be treated with antithyroid drugs, radioactive iodine, or surgery. Side effects of antithyroid drugs are rare but dangerous. In addition, hyperthyroidism can reactivate. Because the initial surgery results are greater than those after iodine-131 treatment, radioactive iodine is the treatment of choice for most patients [12-14].

Iodine-131 was introduced about 80 years ago to treat hyperthyroidism. This radiopharmaceutical is very powerful, cheap, and safe. The most crucial advantage of radioactive iodine treatment is its simplicity of effectiveness and short-time response [15, 16]. It should be noted that among the radiopharmaceuticals used in medicine for diagnostic and therapeutic applications, the physical properties of iodine-131 are more desirable for treating hyperthyroidism [17, 18]. This radiopharmaceutical has beta and gamma radiation and has a half-life of about eight days. Iodine-131 has no diagnostic application due to its long half-life but is effective in thyroid destruction due to beta radiation [19, 20]. The goals and methods of presenting iodine-131 are various in different institutions. Some physicians prescribe a dose of 5 to 30 mCi, while others have adopted dosimetry approaches based on the retest of radioactive iodine uptake and thyroid volume [21, 22]. However, the dose received in each region varies according to economic differences. The main disadvantage of using iodine-131 is that it leads to unacceptable hypothyroidism. Also, after one therapeutic dose, people treated with iodine-131 can expose those around them to excreting the activity in their urine, saliva, or sweat [23-25]. As a result, the patient can be an important source of exposure for people near them [24, 26]. Based on a retrospective study conducted in 2016, in terms of thyroid gland weight and other clinical factors, the required dose of I-131 was calculated according to the following formula [27]: Dose of iodine-131 in millicuries = Mass of thyroid gland in grams *0.235.

Exposure is the amount of electric charge generated by electromagnetic ionizing radiations per unit mass of air, expressed in roentgen [28]. The exposure directly shows the amount of ionization by air-filled radiation detectors. The adequate atomic number of air and soft tissue within the photon energy range used in radiology is approximately proportional to the dose [29]. However, the quantity of exposure is only used to interact with energetic ionizing photons such as X-rays and gamma rays [30, 31].

Due to beta radiation by iodine-131, hyperthyroid patients, even after treatment, can still infect the treatment staff and people near them in one place as a source of radiation [32]. Therefore, isolation of patients is required after iodine therapy for the period recommended by the physician, which is based on the prescribed dose and ER measured at a distance of one meter from the patient [24].

BMI shows the weight (kg) ratio to height (meters). This index is independent of age and gender. The WHO world site divides people into four categories in terms of BMI:

Low weight: Adult with BMI below 18.5; Suitable weight: Adult with BMI between 18.5 to 24.9; Overweight: Adult with BMI between 25 to 29.9; Obese: Adult with BMI of 30 or higher.

Since BMI is a good indicator for calculating body fat in many people, it can be used as a health risk indicator. People with high BMI may be at risk for high blood cholesterol or other fatty disorders, type 1 diabetes, heart disease, stroke, high blood pressure, cancer, gallbladder disease, or premature death. However, BMI cannot provide complete information about the body's composition (muscle, bone, fat, and other tissues). People with large or tiny bodies, pregnant women, and very muscular people need more accurate evaluation and interpretation. The relationship between BMI and radiation dose in mammography, radiography, CT scan, and angiography has been discussed in various articles. Still, we did not find any evidence in nuclear medicine papers [28, 33-35].

Because the prevalence of hyperthyroidism has increased in recent decades and obesity has been recognized as an independent factor in the incidence of hyperthyroidism, in this arti-

Table 1. Anthropometric measurements and radiation data of patients

	Overall (N=30)
Age	
Mean (SD)	44.3 (14.3)
Median [Min, Max]	39.5 [25.0, 79.0]
Height	
Mean (SD)	166 (10.0)
Median [Min, Max]	166 [135, 186]
Weight	
Mean (SD)	69.9 (14.0)
Median [Min, Max]	68.0 [43.0, 112]
Body Mass Index	
Mean (SD)	25.6 (5.84)
Median [Min, Max]	24.0 [17.0, 47.0]
I-131 Activity	
Mean (SD)	17.5 (5.41)
Median [Min, Max]	18.0 [8.00, 29.0]
Exposure Rate	
Mean (SD)	51.3 (11.4)
Median [Min, Max]	50.0 [30.0, 85.0]

cle, we studied the correlation between BMI and ER (exposure rate) of hyperthyroid patients treated with iodine-131 from various aspects so that if there is a relation, we can improve the prescribed dose for the treatment of hyperthyroid patients.

Materials and methods

Subjects

In this analytical and cross-sectional study, 30 patients with hyperthyroidism treated with liquid iodine-131 from residents of Babol city in Alborz Nuclear Medicine Center were randomly selected and studied separately without any grouping from 2016/12/12 to 2017/8/5. For this study, the code of ethics with the ID of IR.MUBABOL.HRI.REC.1398.351 has been issued by the Health Research Institute of Babol University of Medical Sciences. All patients had signed informed consent to permit the use of their demographic indicators, including age (y), height (m), and weight (kg).

Method

Patients were treated with the activity of 8-29 mCi (mean 14.4 mCi) oral I-131. A "Monitor Dosimeter 5" device was used to measure the external radiation of patients. An expert in medical physics measured external exposure from a distance of one meter parallel to the patient's thyroid gland at intervals of 6 to 24 hours post-iodine-131 administration and he used a lead gown to provide maximum protection from external radiation.

Table 2. Correlation test between Iodine activity and external exposure rate

data: data$IA and data$ER
t =3.3455, df =28, *P*-value =0.00235
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval: 0.2156349 0.7502226
sample estimates: cor 0.5343893

Statistical analysis

ER measurements and other acquired data were presented in an Excel spreadsheet and were statistically analyzed by R software and its methods. Data were normalized using the Shapiro method, and due to the non-normality of the data in the correlation test, the Spearman method was used.

Results

The mean and variance of radiation measured by a dosimeter device at a distance of one meter from patients and the activity of iodine-131, along with the mean and variance of anthropometric findings of patients, are summarized in **Table 1**.

Findings show no significant relationship between exposure and BMI (rho =-0.032, *P*-value =0.082>0.05). Also, a Pearson correlation coefficient was computed to assess the relationship between the iodine-131 activity (IA) and external exposure rate (ER) in **Table 2**. There was a positive correlation between the two variables (r=0.534, n=5, P=0.002). **Figure 1** shows a significant relationship between exposure and iodine activity. Overall, there was a strong, positive correlation between iodine-131 activity and external exposure rate. Increases in iodine-131 activity administration were correlated with increases in external exposure rate. A pair plot summarizes the results (**Figure 2**).

Discussion

The measurements of this study represent two main findings:

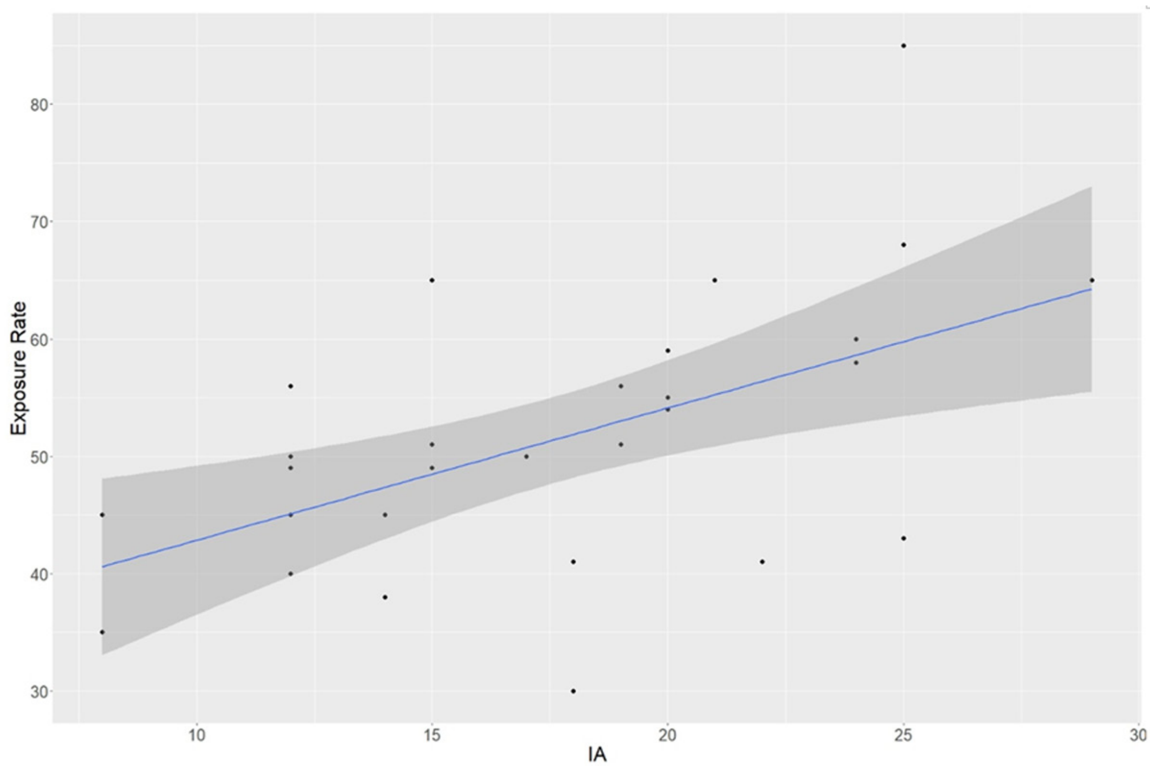

Figure 1. Variation in external exposure rate with the iodine-131 activity, including the linear regression line.

1) By comparing the administered dose with external radiation, it can be concluded that there is a significant relationship between ER and iodine-131 activity because the observed significance level (*P*-value =0.002) is smaller than the predicted error value (0.01) and therefore it is effective on radiation to the environment. 2) The present study's findings show a negative relationship between BMI and ER but it is not statistically significant because the observed significance level (*P*-value =0.082) is greater than the predicted error value (0.05).

Finding an indicator for ER to minimize the environmental pollution caused by radiation of a patient treated with iodine-131 was the primary concern of the authors of this study because unnecessary and excessive administration of radioactive iodine increases the pollution and its effects on the body and the environment [36].

In a study conducted by Ka-Kit Wong et al. to evaluate the success rate of iodine-131 in eliminating Graves-induced hyperthyroidism, more than 90% of patients were treated with iodine-131, indicating a high success rate of iodine-131 in the treatment of the disease [21]. On the other hand, in a study conducted in 2019, the correlation between the incidence of papillary thyroid cancer and BMI showed that the higher the BMI, the larger the size of the tumor and the more likely it is to be multifocal. Also, a study to examine the correlation between BMI and the incidence of thyroid cancer found a positive relationship between thyroid cancer incidence and high BMI in men and women under the age of 50 [37, 38]. In a study by Charles A. Pickering et al. (2014), the relationship between ER data and measured demographic data (age, sex, height, weight, and BMI) in patients with thyroid cancer was investigated. In that study, comparing the normalized radiation data of patients with demographic findings showed that only weight and BMI have a significant linear correlation with external radiation. Also, Yahia Lahfi et al. (2014) investigated the relationship between BMI and dose excreted from patients with thyroid cancer. The result of measuring the amount of radiation at intervals of 1, 24, and 48 hours after iodine-131 administration in patients with normal BMI was 11% higher than in patients with overweight and obesity. This amount, however, reached 49% in patients receiving a dose of 100 mCi. Since these studies show a significant relation-

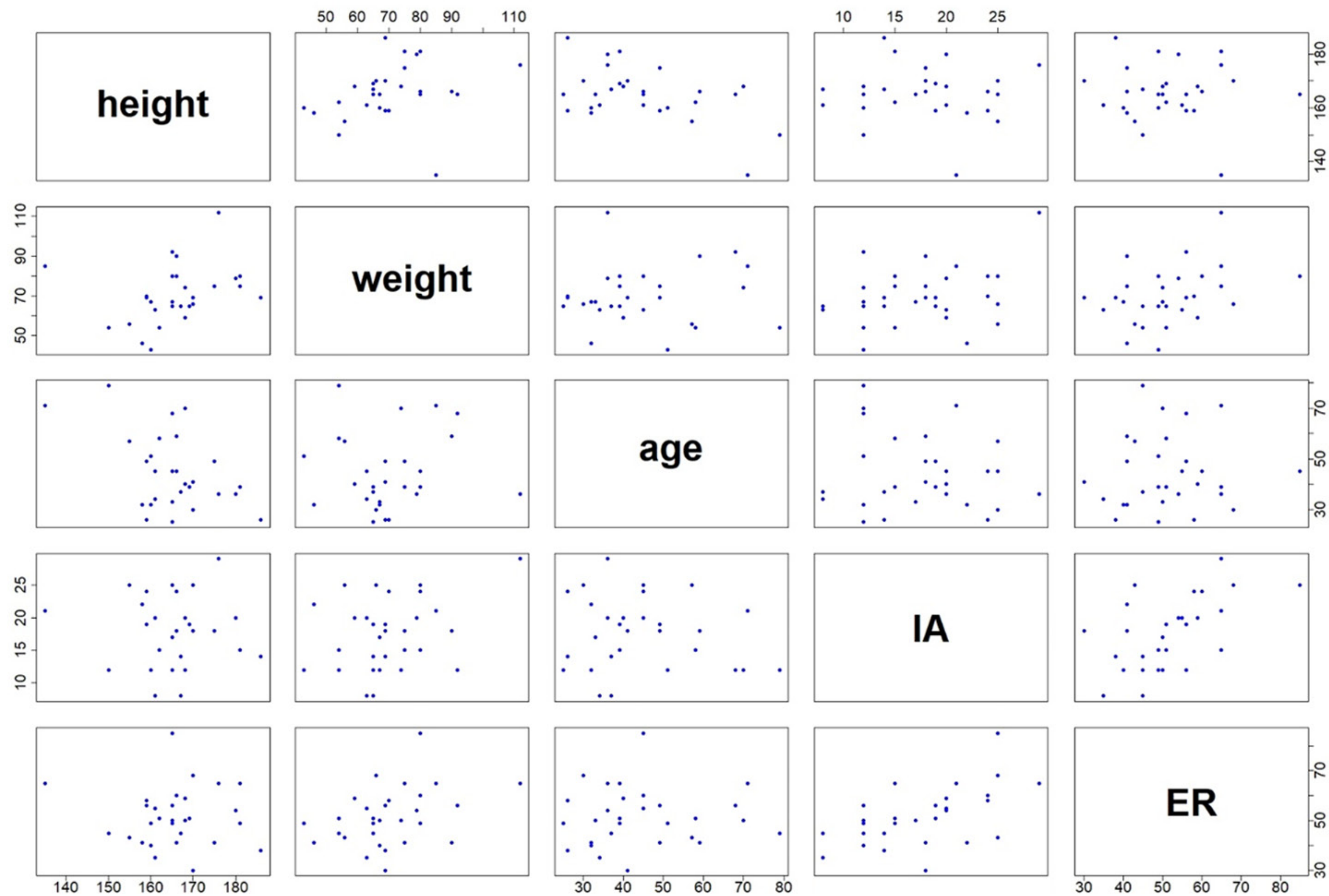

Figure 2. Height, Weight, Age, Iodine-131 activity, and External exposure rate pair plots.

ship between BMI and external radiation, it can be said that the findings of the present study do not adequately reflect the results of these two reports [39, 40]. Studies on the parameters of weight, BMI, and iodine-131 show that the effect of the first two factors on radiation was not as significant as the activity parameter of iodine-131 orally taken [40]. Therefore, by examining the correlations between BMI and ER, it can be concluded that the amount of radiation of patients with hyperthyroidism treated with iodine-131, which affect the environment, can be minimized by using less iodine activity. But, our initial results show that the negative relationship between BMI and ER is not statistically significant, which is different from previous studies, further study is required to study impact of BMI on ER.

The study can be further improved by increasing the sample size and number of patients. Also, studying the impact of gender is indeed very important. In our future work, we will investigate the impact of patient gender on a large group of patients.

Disclosure of conflict of interest

None.

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