Age-related Changes of Br, Ca, Cl, I, K, Mg, Mn, and Na Contents in Intact Thyroid of Males Investigated by Neutron Activation Analysis

Vladimir Zaichick1*, Sofia Zaichick2
1Radionuclide Diagnostics Department, Medical Radiological Research Centre, Obninsk, Russia
2Feinberg School of Medicine, Northwestern University, Chicago, USA

Abstract

A prevalence of thyroid dysfunction is higher in the elderly as compared to the younger population. An excess or deficiency of chemical element contents in thyroid may play important role in goitro- and carcinogenesis of gland. The variation with age of the mass fraction of eight chemical elements (Br, Ca, Cl, I, K, Mg, Mn, and Na) in intact (normal) thyroid of 72 males (mean age 37.8 years, range 2-80 years) was investigated by instrumental neutron activation analysis with high resolution spectrometry of short-lived radionuclides. Mean values and standard error of mean for mass fractions (mg/kg, on dry-mass basis) of the chemical elements studied were: Br 13.7±1.0, Ca 1703±131, Cl 3449±219, I 1786±940, K 6289±329, Mg 306±19, Mn 1.31±0.07, and Na 6820±214. This work revealed that there is a statistically significant increase in Ca and I mass fraction, as well as a decrease in K and Mn mass fraction in the normal thyroid of male during a lifespan. Moreover, a disturbance of intrathyroidal chemical element relationships with increasing age was found. Therefore, a goitrogenic and carcinogenic effect of inadequate Ca, I, K, and Mn level in the thyroid of old males and a harmful impact of disturbance on intrathyroidal chemical element relationships with increasing age may be assumed.

INTRODUCTION

The endocrine organs, including the thyroid gland, undergo important functional changes during aging and a prevalence of thyroid dysfunction is higher in the elderly as compared to the younger population [1,2]. Advancing age is known to influence the formation of adenomatous goiter and thyroid cancer [3]. The prevalence of thyroid nodules is increased in the elderly, reaching a frequency of nearly 50% by the age of 65 [4]. Both prevalence and aggressiveness of thyroid cancer increase with age [2]. Women are affected by thyroid nodule and cancer two to five times more often than men, but in age over 65 years a prevalence of thyroid cancer may be higher in men [2-4,5].

Aging is characterized by progressive impairment of body functions caused by the accumulation of molecular damage in DNA, proteins and lipids, is also characterized by an increase in intracellular oxidative stress due to the progressive decrease of the intracellular reactive oxygen species (ROS) scavenging [6,7]. Oxidative damage to cellular macromolecules which induce age-related diseases, including cancer, can also arise through overproduction of ROS and faulty antioxidant and/or DNA repair mechanisms [8]. Overproduction of ROS is associated with stress, inflammation, radiation, and some other factors, including overload of certain chemical elements, in both blood and certain tissues, or deficiency of other chemical elements with antioxidant properties [9-15]. The imbalance in the composition of chemical elements in cells, tissues and organs may cause different types of pathology. The importance of appropriate levels of many chemical elements is indisputable, due to their beneficial roles when present in specific concentration ranges, while on the other hand they can cause toxic effects with excessively high or low concentrations [12].

In our previous studies [16-24] the high mass fraction of iodine and some other chemical element were observed in intact human thyroid gland when compared with their levels in non-thyroid soft tissues of the human body. However, the age-dependence of chemical element mass fraction in thyroid of adult and, particularly, elderly males is still need to be evaluated. One valuable way to elucidate the situation is to compare the mass fractions of chemical elements in young adult (the control group) with those in older adult and geriatric thyroid. The findings of the excess or deficiency of chemical element contents in thyroid and
the perturbations of their relative proportions in glands of adult and elderly males, may indicate their roles in a higher prevalence of thyroid dysfunction in the elderly population.

The reliable data on chemical element mass fractions in normal geriatric thyroid is apparently extremely limited. There are multiple studies reporting chemical element content in human thyroid, using chemical techniques and instrumental methods [25-36]. However, majority of the analytical methods currently used and validated for the determination of major and trace elements in thyroid and other human organs are based on techniques requiring sample digestion. The most frequently used digestion procedures are the traditional dry ashing and high-pressure wet digestion that cause destruction of organic matter of the sample. Sample digestion is a critical step in elemental analysis and due to the risk of contamination and analytes loss, a digestion step contributes to the systematic uncontrolled analysis errors [37-39]. Moreover, only a few of the previous studies employed quality control using certified/standard reference materials (CRM/SRM) for determination of the chemical element mass fractions. Therefore, sample-nondestructive technique like instrumental neutron activation analysis with high resolution spectrometry of short-lived radionuclides (INAA-SLR) combined with a quality assurance using CRM/SRM is good alternatives for multielement determination in the samples of thyroid parenchyma.

There were three aims in this study. The primary purpose of the study was to determine reliable values for the bromine (Br), calcium (Ca), chlorine (Cl), iodine (I), potassium (K), magnesium (Mg), manganese (Mn), and sodium (Na) mass fractions in the normal (intact) thyroid of subjects ranging from children to elderly males using INAA-SLR. The second aim was to compare the Br, Ca, Cl, I, K, Mg, Mn, and Na mass fractions in thyroid gland of age group 2 (adults and elderly persons aged 36 to 80 years), with those of group 1 (from 2 to 35 years) and to find the correlations between age and chemical element contents, and the final aim was to find the inter-correlations of chemical elements in normal thyroid of males and their changes with age.

All studies were approved by the Ethical Committee of the Medical Radiological Research Center.

**MATERIALS AND METHODS**

**Subjects and Sample Preparation**

Samples of the human thyroid were obtained from randomly selected autopsy specimens of 72 males (European-Caucasian) aged 2 to 80 years. All the deceased were citizens of Obninsk and had undergone routine autopsy at the Forensic Medicine Department of City Hospital, Obninsk. Subjects were divided into two age groups, group 1 with 2-35 years (22.3±1.4 years, M±SEM, n=36) and group 2 with 36–80 years (53.3±2.5 years, M±SEM, n=36). These groups were selected to reflect the condition of the Br, Ca, Cl, I, K, Mg, Mn, and Na mass fractions in the thyroid tissue in the children, teenagers, young adults and first period of adult life (group 1) and in the second period of adult life as well as in old age (group 2). The available clinical data were reviewed for each subject. None of the subjects had a history of an intersex condition, endocrine disorder, or other chronic disease that could affect the normal development of the thyroid. None of the subjects were receiving medications or used any supplements known to affect thyroid chemical element contents. The typical causes of sudden death of most of these subjects included trauma or suicide and also acute illness (cardiac insufficiency, stroke, embolism of pulmonary artery, alcohol poisoning). All right lobes of thyroid glands were divided into two portions using a titanium scalpel [40]. One tissue portion was reviewed by an anatomical pathologist while the other was used for the chemical element content determination. A histological examination was used to control the age norm conformity as well as the unavailability of microadenomatosis and latent cancer.

After the samples intended for chemical element analysis were weighed, they were transferred to -20°C and stored until the day of transportation in the Medical Radiological Research Center, Obninsk, where all samples were freeze-dried and homogenized [41]. The pounded sample weighing about 100 mg was used for chemical element measurement by INAA-SLR. The samples for INAA-SLR were sealed separately in thin polyethylene films washed beforehand with acetone and rectified alcohol. The sealed samples were placed in labeled polyethylene ampoules.

**Preparation of Standards**

To determine contents of the elements by comparison with a known standard, biological synthetic standards (BSS) were prepared from phenol-formaldehyde resins [42]. In addition to BSS, aliquots of commercially available pure compounds were also used as standards. Ten certified reference material (CRM) IAEA H-4 (animal muscle) sub-samples weighing about 100 mg were treated and analyzed in the same conditions that thyroid samples to estimate the precision and accuracy of results.

**Irradiation**

The content of Br, Ca, Cl, I, K, Mg, Mn, and Na were determined by INAA-SLR using a horizontal channel equipped with the pneumatic rabbit system of the WWR-c research nuclear reactor. The neutron flux in the channel was 1.7 × 10^{13} cm^{-2} s^{-1}. Ampoules with thyroid tissue samples, SSB, intralaboratory-made standards, and certified reference material were put into polyethylene rabbits and then irradiated separately for 180 s. Copper foils were used to assess neutron flux.

The measurement of each sample was made twice, 1 and 120 min after irradiation. The duration of the first and second measurements was 10 and 20 min, respectively. Spectrometric measurements were performed using a coaxial 98-cm3 Ge (Li) detector and a spectrometric unit (NUC 8100), including a PC-coupled multichannel analyzer. Resolution of the spectrometric unit was 2.9-keV at the 60Co 1,332-keV line. Details of used nuclear reactions, radionuclides, and gamma-energies were reported in our earlier publications concerning the INAA chemical element contents in human scalp hair [17,43].

**Statistical Analysis**

The neutron flux in the channel was 1.7 × 10^{13} cm^{-2} s^{-1}. Ampoules with thyroid tissue samples, SSB, intralaboratory-made standards, and certified reference material were put into polyethylene rabbits and then irradiated separately for 180 s. Copper foils were used to assess neutron flux.
RESULTS

Table 1 indicates our data for eight chemical elements in ten sub-samples of CRM IAEA H-4 (animal muscle) and the certified values of this material.

Table 2 represents certain statistical parameters (arithmetic mean, standard deviation, standard error of mean, minimal and maximal values, median, percentiles with 0.025 and 0.975 levels) of the Br, Ca, Cl, I, K, Mg, Mn, and Na contents in intact (normal) thyroid of males.

The comparison of our results with published data for the Br, Ca, Cl, I, K, Mg, Mn, and Na contents in normal thyroid according to data from the literature is shown in Table 3.

To estimate the effect of age on the chemical element contents we examined two age groups, described above (Table 4).

Table 1: INAA-SLR data of chemical element contents in the IAEA H-4 (animal muscle) reference material compared to certified values (mg/kg, dry mass basis)

<table>
<thead>
<tr>
<th>Element</th>
<th>Certified values</th>
<th>This work results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>95% confidence interval</td>
</tr>
<tr>
<td>Br</td>
<td>4.1</td>
<td>3.5 – 4.7</td>
</tr>
<tr>
<td>Ca</td>
<td>188</td>
<td>163 – 213</td>
</tr>
<tr>
<td>Cl</td>
<td>1890</td>
<td>1810 – 1970</td>
</tr>
<tr>
<td>I</td>
<td>0.08</td>
<td>-</td>
</tr>
<tr>
<td>K</td>
<td>15800</td>
<td>15300 – 16400</td>
</tr>
<tr>
<td>Mg</td>
<td>1050</td>
<td>990 – 1110</td>
</tr>
<tr>
<td>Mn</td>
<td>0.52</td>
<td>0.48 – 0.55</td>
</tr>
<tr>
<td>Na</td>
<td>2060</td>
<td>1930 – 2180</td>
</tr>
</tbody>
</table>

Abbreviations: Mean: Arithmetic Mean; SD: Standard Deviation; Type: Certified values; N: Non-certified values

Table 2: Some statistical parameters of Br, Ca, Cl, I, K, Mg, Mn, and Na mass fraction (mg/kg, dry mass basis) in intact thyroid of male (n=72)

Table 3: Median, minimum and maximum value of means Br, Ca, Cl, I, K, Mg, Mn, and Na contents in normal thyroid according to data from the literature in comparison with our results (mg/kg, dry mass basis)

Table 4: Differences between mean values (M±SEM) of Br, Ca, Cl, I, K, Mg, Mn, and Na mass fraction (mg/kg, dry mass basis) in normal male thyroid of two age groups (AG)

<table>
<thead>
<tr>
<th>Element</th>
<th>AG1 2.0-35 years</th>
<th>AG2 36-80 years</th>
<th>t-test</th>
<th>U-test</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Br</td>
<td>12.1±1.5</td>
<td>15.0±1.3</td>
<td>0.162</td>
<td>&gt;0.05</td>
<td>1.24</td>
</tr>
<tr>
<td>Ca</td>
<td>1495±107</td>
<td>1899±230</td>
<td>0.119</td>
<td>&gt;0.05</td>
<td>1.27</td>
</tr>
<tr>
<td>Cl</td>
<td>3403±474</td>
<td>3478±273</td>
<td>0.872</td>
<td>&gt;0.05</td>
<td>1.02</td>
</tr>
<tr>
<td>I</td>
<td>1627±164</td>
<td>1930±169</td>
<td>0.203</td>
<td>&gt;0.05</td>
<td>1.19</td>
</tr>
<tr>
<td>K</td>
<td>7015±435</td>
<td>5651±465</td>
<td>0.036</td>
<td>≤0.01</td>
<td>0.81</td>
</tr>
<tr>
<td>Mg</td>
<td>326±20</td>
<td>286±33</td>
<td>0.3</td>
<td>&gt;0.05</td>
<td>0.88</td>
</tr>
<tr>
<td>Mn</td>
<td>1.50±0.09</td>
<td>1.14±0.08</td>
<td>0.006</td>
<td>≤0.01</td>
<td>0.76</td>
</tr>
<tr>
<td>Na</td>
<td>6978±321</td>
<td>6675±289</td>
<td>0.485</td>
<td>&gt;0.05</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Abbreviations: M: Arithmetic Mean; SEM: Standard Error of Mean; t-test: Student’s t-test; U-test: Wilcoxon-Mann-Whitney U-test; Statistically significant values are in bold

A dedicated computer program for INAA mode optimization was used [44]. All thyroid samples were prepared in duplicate, and mean values of chemical element contents were used in final calculation. Using Microsoft Office Excel, a summary of the statistics, including, arithmetic mean, standard deviation, standard error of mean, minimum and maximum values, median, percentiles with 0.025 and 0.975 levels was calculated for chemical element contents. The difference in the results between two age groups was evaluated by the parametric Student’s t-test and non-parametric Wilcoxon-Mann-Whitney U-test. For the construction of “age – chemical element mass fraction” diagrams (including lines of trend with age) and the estimation of the Pearson correlation coefficient between age and chemical element mass fraction as well as between different chemical elements the Microsoft Office Excel programs were also used. To identify the trend of the age dependency of Br, Ca, Cl, I, K, Mg, Mn, and Na contents, we applied approximation methods using exponential, linear, polynomial, logarithmic and power function. The maximum of corresponding values of R² parameter, reflecting the accuracy of approximation, was used for the selection of function.

Email: vezai@obninsk.com
Figure 1: Data sets of individual Br, Ca, Cl, I, K, Mg, Mn, and Na mass fraction values in intact thyroid of males and their trend lines.
In addition, the Pearson correlation coefficient between age and trace element mass fraction was calculated (Table 5). Figure 1 shows the individual data sets for the Br, Ca, Cl, I, K, Mg, Mn, and Na mass fraction in all samples of thyroid, and also lines of trend with age. Since the age dependency of these element contents was best described by a polynomial function, this approximation was reflected in Figure 1.

### Table 5: Pearson’s correlations between age and chemical element mass fractions in the normal thyroid of male (r - coefficient of correlation)

<table>
<thead>
<tr>
<th>Element</th>
<th>Br</th>
<th>Ca</th>
<th>Cl</th>
<th>I</th>
<th>K</th>
<th>Mg</th>
<th>Mn</th>
<th>Na</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.11</td>
<td>0.41</td>
<td>0.11</td>
<td>0.32</td>
<td>-0.31</td>
<td>0.10</td>
<td>-0.38</td>
<td>-0.10</td>
</tr>
</tbody>
</table>

Statistically significant values: *p<0.05, † p<0.01, ‡ p<0.001

The obtained means for Br, Ca, Cl, I, K, Mg, Mn, and Na mass fraction were not expressed on a dry mass basis by the authors of the cited references. However, we calculated these values using published data for water (75%) [45] and ash (4.16% on dry mass basis) [46] contents in thyroid of adults.

A statistically significant age-related decrease in K and Mn mass fraction was observed in thyroid of males (Table 4) when two age groups were compared. In second group of males with mean age 53.3 years the mean K and Mn mass fraction in thyroids were 19% and 24%, respectively, lower than in thyroids of the first age group (mean age 22.3 years). A statistically significant decrease in K and Mn mass fraction with age was confirmed by the negative Pearson’s coefficient of correlation between age and mass fractions of these elements (Table 5). There were no found statistically significant differences between the Br, Ca, Cl, I, Mg, and Na mass fractions within two different age-groups. However a statistically significant increase in Ca, and I mass fraction with increasing of age was shown by the positive Pearson’s coefficient of correlation between age and mass fractions of these elements (Table 5, Figure 1). As per author’s current information, no published data referring to age-related changes of Br, Ca, Cl, I, K, Mg, Mn, and Na mass fractions in human thyroid is available.

Table 5: Pearson’s correlations between age and chemical element mass fractions in the normal thyroid of male (r - coefficient of correlation)

<table>
<thead>
<tr>
<th>Pair of elements</th>
<th>2-35 years</th>
<th>36-80 years</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p</td>
<td>r</td>
</tr>
<tr>
<td>Br-Mn</td>
<td>0.46</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>Ca-I</td>
<td>0.52</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Ca-Mn</td>
<td>0.34</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>I-Mg</td>
<td>-0.33</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>I-Na</td>
<td>-0.42</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>Mg-Mn</td>
<td>0.49</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Mg-Na</td>
<td>0.42</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>Cl-K</td>
<td>-0.37</td>
<td>0.05</td>
<td>-0.50</td>
</tr>
<tr>
<td>Cl-Na</td>
<td>0.30</td>
<td>0.05</td>
<td>0.65</td>
</tr>
<tr>
<td>Br-Cl</td>
<td>-</td>
<td>-</td>
<td>-0.36</td>
</tr>
</tbody>
</table>

Abbreviations: *: no statistically significant correlation

The data of inter-correlation calculations (values of r - coefficient of correlation) including all chemical elements identified by us are presented in Table 6.

### Table 6: Intercorrelations of the chemical element mass fractions in the intact thyroid of male of two age groups (r - coefficient of correlation)

<table>
<thead>
<tr>
<th>Pair of elements</th>
<th>Age 2-35 years</th>
<th>Age 36-80 years</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p</td>
<td>r</td>
</tr>
<tr>
<td>Br-Mn</td>
<td>0.46</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>Ca-I</td>
<td>0.52</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Ca-Mn</td>
<td>0.34</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>I-Mg</td>
<td>-0.33</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>I-Na</td>
<td>-0.42</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>Mg-Mn</td>
<td>0.49</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Mg-Na</td>
<td>0.42</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>Cl-K</td>
<td>-0.37</td>
<td>0.05</td>
<td>-0.50</td>
</tr>
<tr>
<td>Cl-Na</td>
<td>0.30</td>
<td>0.05</td>
<td>0.65</td>
</tr>
<tr>
<td>Br-Cl</td>
<td>-</td>
<td>-</td>
<td>-0.36</td>
</tr>
</tbody>
</table>

Abbreviations: *: no statistically significant correlation

The obtained means for Br, Ca, Cl, I, K, Mg, Mn, and Na mass fraction, as shown in Table 3, agree well with the medians of mean values reported by other researches for the human thyroid, including samples received from persons who died from different non-thyroid diseases [25-36]. A number of values for chemical element mass fractions were not expressed on a dry mass basis by the authors of the cited references. However, we calculated these values using published data for water (75%) [45] and ash (4.16% on dry mass basis) [46] contents in thyroid of adults.

DISCUSSION

A good agreement of the Br, Ca, Cl, I, K, Mg, Mn, and Na contents analyzed by INAA-SLR with the certified data of CRM IAEA H-4 (Table 1) demonstrates an acceptable accuracy of the results obtained in the study of chemical elements of the thyroid presented in Tables 2-5.

The obtained means for Br, Ca, Cl, I, K, Mg, Mn, and Na mass fraction, as shown in Table 3, agree well with the medians of mean values reported by other researches for the human thyroid, including samples received from persons who died from different non-thyroid diseases [25-36]. A number of values for chemical element mass fractions were not expressed on a dry mass basis by the authors of the cited references. However, we calculated these values using published data for water (75%) [45] and ash (4.16% on dry mass basis) [46] contents in thyroid of adults.

A significant direct correlation, for example, between the Mn and Br, Mn and Ca, Mn and Mg, Ca and I mass fractions as well as an inverse correlation between I and Mg, I and Na mass fractions was seen in male thyroid of the first age group (Table 6). In age group 2 many correlations between chemical elements in thyroid found in the age group 1 are no longer evident (Table 6). For example, all correlations between Mn and other chemical elements as well as between I and other chemical elements, existed in the age from 2 to 35 years, disappeared but new inverse correlation Br-Cl was arisen. Thus, if we accept the levels and relationships of chemical element mass fraction in thyroid glands of males in the age range 2 to 35 years as a norm, we must conclude that after age 35 years the level of K and Mn, as well as relationships of chemical elements in thyroid significantly changed. If some positive correlations between the elements in the group 1 were predictable (e.g., Na-Cl), the interpretation of other observed relationships and their perturbation with age requires further study for a complete understanding. No published data on inter-correlations of Br, Ca, Cl, I, K, Mg, Mn, and Na mass fractions in human thyroid and age-related changes of these inter-correlations was found.

An age-related increase and excess in Ca mass fractions in thyroid tissue may contribute to harmful effects on the gland. There are good reasons for such speculations since many reviews and numerous papers raise the concern about role of Ca in the prostate, breast, lung and other organ malignant transformation [47-72]. Calcium ions Ca \(^{2+}\) are central to both cell proliferation for tumorigenesis, such as cellular motility, proliferation and apoptosis [52,53]. Changes in cytosolic Ca \(^{2+}\) trigger events critical for tumorogenesis, such as cellular motility, proliferation and apoptosis [52,53]. An increased growth rate of cells is correlated with an increase in the intracellular calcium pool content [47,48]. Moreover, increases in cytosolic free Ca \(^{2+}\) represent a ubiquitous signaling mechanism that controls a variety of cellular processes, including not only proliferation, but also cell metabolism and gene transcription [51]. Indeed, an increased level of Ca content in the thyroid tissue of old males reflects an increase in the intracellular calcium pool. Thus, an increase of Ca content in tissue and organs with age is a key feature in etiology of many benign and malignant tumors, including thyroid goiter and cancer.

It is well known that excess in I mass fractions in thyroid
tissue may contribute to harmful effects on the gland [19, 21, 73-76]. Because K+ is mainly an intracellular electrolyte, a decreased level of K content in the thyroid tissue of old males might indicate an age-related decrease of ratio “thyroid cell mass – follicular colloid mass”. From the other hand, mass fraction of Na does not change during a lifespan (Table 4, Figure 1). From this it follows that an intracellular Na+:K+ ratio in thyroid of old males may be higher normal level. In turn, increasing intracellular Na+:K+ ratio is associated with a depolarization of the cell membrane [77]. The sustained depolarization of the cell membrane results in an increased rate of cell division and in that way with an increased risk of goiter, benign and malignant tumor of thyroid.

It was reported that intracellular Mn content was positively correlated with manganese-containing superoxide dismutase (Mn-SOD), suggesting that the intracellular Mn level is associated with Mn-SOD activity [78]. Thus, a decrease of Mn content in thyroid parenchyma with age indicates the deficiency of antioxidant enzymes in the gland of old males.

All the samples were obtained from deceased citizens of Obninsk. Obninsk is the small nonindustrial city not far from Moscow in unpolluted area. None of the subjects include in this study had suffered from any systematic or chronic disorders before their sudden death. The normal state of thyroid gland was confirmed by morphological examination. Thus, our data on Br, Ca, Cl, I, K, Mg, Mn, and Na mass fractions in intact thyroid may indicate normal values for males of urban population of the Russian Central European region.

CONCLUSION

The instrumental neutron activation analysis with high resolution spectrometry of short-lived radionuclides is a useful analytical tool for the non-destructive determination of chemical element content in the thyroid tissue samples. This method allows determine the mean of content for Br, Ca, Cl, I, K, Mg, Mn, and Na (8 chemical elements).

Our data elucidate that there is a statistically significant increase in Ca and I mass fraction, as well as a decrease in K and Mn mass fraction in the normal thyroid of male during a lifespan. Moreover, a disturbance of intrathyroidal chemical element relationships with increasing age was found. Therefore, a goitrogenic and carcinogenic effect of inadequate Ca, I, K, and Mn level in the thyroid of old males and a harmful impact of disturbance in intrathyroidal chemical element relationships with increasing age may be assumed.

ACKNOWLEDGEMENT

We are grateful to Dr. Yu Chorporov, Head of the Forensic Medicine Department of City Hospital, Obninsk, for supplying thyroid samples. We are also grateful to three anonymous reviewers for their comments and peer-review.

DISCLOSURE

There is no any financial interest or any conflict of interest.

REFERENCES

20. Zaichick V. In vivo and in vitro application of energy-dispersive XRF in...


33. Kortev AI, Donthov GI, Lysacheva AP. Bioelements and a human pathology. Sverdlovsk, Russia. Middle-Unal publishing-house. 1972.


44. Korelo AM, Zaichick V. Software to optimize the multielement INAA of medical and environmental samples. In: Activation Analysis in Environment Protection. Dubna, Russia: Joint Institute for Nuclear Research. 1993; 326-332.


54. Yang H, Zhang Q, He J, Lu W. Regulation of calcium signaling in lung...


64. Zaichick V, Zaichick S. Prostatic tissue levels of some androgen dependent and independent trace elements in patients with benign prostatic hyperplasia. Androl Gynecol: Curr Res. 2015; 3: 3.


About the Corresponding Author

Dr. Vladimir Zaichick

Summary of background:

Vladimir Zaichick has completed his PhD at the age of 29 years from Institute of Biophysics, Moscow, and his DSc degree and Professor rank from Medical Radiological Research Center, Obninsk, Russia. He is a member of the Scientific Council on Analytical Chemistry of the Russian Academy of Sciences, a fellow of the British Royal Society of Chemistry and Chartered Chemist (since 1996), and a member of some other Scientific Societies. He has published more than 300 papers in reputed journals and 19 patents. He is serving as an editorial board member of few scientific journals.

Current position - professor, principal investigator.

Permanent e-mail address: vezai@obninsk.com

Current research focus:

- Nuclear and relative analytical methods for in vitro and in vivo investigation of chemical element contents in human tissue, organs and fluids suitable for using in medical studies.
- Age- and gender-dependence of chemical element contents in tissues and fluids of human body.
- Role of chemical element contents in tissues and fluids of human body in normal and pathophysiology, in ageing and in an aetiology and pathogenesis of age-related diseases, including carcinogenesis.
- Chemical element contents in human tissue, organs and fluids as markers of norm and diseases, including cancer.
- Investigation of chemical element contents in food and diets.

Journal of Aging & Age Related Diseases

Journal of Aging & Age Related Diseases is an international, peer-reviewed journal that aims to publish scholarly papers of highest quality and significance in the field of aging and age related diseases. The journal publishes original research articles, review articles, clinical reports, case studies, commentaries, editorials, and letters to the Editor.

For more information please visit us at following:

Aims and Scopes: https://www.jscimedcentral.com/Aging/aims-scope.php
Editorial Board: https://www.jscimedcentral.com/Aging/editors.php
Author Guidelines: https://www.jscimedcentral.com/Aging/submitpaper.php
Submit your manuscript or e-mail your questions at aging@jscimedcentral.com

Cite this article