



Comparison of thyroid volume and goiter measured by means of ultrasonography and SPECT with use of ^{131}I and $^{99\text{m}}\text{Tc}$ in smokers and non-smokers

Porównanie objętości tarczycy i wola za pomocą ultrasonografii i SPECT z zastosowaniem ^{131}I i $^{99\text{m}}\text{Tc}$ u palaczy papierosów i osób niepalących

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Abstract

Introduction: The aim of the study was to estimate the influence of nicotine on thyroid volume according to patients' sex.

Material and methods: A group of 160 patients with thyroid disorders in their past medical history was examined. Patients were divided into two groups: Group A contained 50 patients with goiter, where the volume of the thyroid was evaluated with use of US and ^{131}I -SPECT; group B contained 50 patients with goiter, where the volume of the thyroid was evaluated with use of US and $^{99\text{m}}\text{Tc}$ -SPECT. There were two control groups: Group A' contained 30 patients with normal volume of the thyroid gland shown by US and ^{131}I -SPECT, and group B' contained 30 patients with normal volume of the thyroid gland shown by US and $^{99\text{m}}\text{Tc}$ -SPECT. The patients from the examined and control groups were divided into two subgroups — smokers and non-smokers.

US of the thyroid gland was made by means of an ALOKA SSD 500 device. SPECT was performed by means of a single-headed gamma camera by Diacam.

Results: The average volume of thyroid gland measured by ^{131}I -SPECT and $^{99\text{m}}\text{Tc}$ -SPECT was significantly larger according to US in the examined and control groups in smokers and non-smokers. We did not show statistically significant correlations between levels of iodine uptake and volumes of goiter evaluated by US examination together with ^{131}I scintigraphy.

Conclusions: Significant differences in average values of thyroid volume between smokers and non-smokers were not observed, which might suggest a lack of goitrogenic activity of tobacco smoke or indicates a potential goitrogenic influence not significant enough in the examined group. (*Pol J Endocrinol* 2009; 60 (6): 437–442)

Key words: goiter, thyroid, US, SPECT

Streszczenie

Wstęp: Celem tego badania było oszacowanie wpływu nikotyny na objętość tarczycy w zależności od płci pacjentów.

Materiał i metody: Przebadano grupę 160 pacjentów z chorobami tarczycy w wywiadzie. Pacjentów podzielono na dwie grupy. Grupa A składała się z 50 pacjentów z wolem, u których objętość tarczycy oceniano za pomocą USG i ^{131}I -SPECT. Grupa B składała się z 50 pacjentów z wolem, u których objętość tarczycy oceniano za pomocą USG i $^{99\text{m}}\text{Tc}$ -SPECT. Stworzono dwie grupy kontrolne. Grupa A' składała się z 30 pacjentów z prawidłową objętością tarczycy w ocenie USG i ^{131}I -SPECT i grupa B' składająca się z 30 pacjentów z prawidłową objętością tarczycy w ocenie USG i $^{99\text{m}}\text{Tc}$ -SPECT. Pacjentów z grup badanej i kontrolnej podzielono na 2 podgrupy — palaczy i osoby niepalące. Badania ultrasonograficzne tarczycy wykonywano za pomocą aparatu ALOKA SSD 500. Badanie SPECT przeprowadzono z zastosowaniem gammakamery Diacam.

Wyniki: Średnia objętość tarczycy oszacowana za pomocą ^{131}I -SPECT o $^{99\text{m}}\text{Tc}$ -SPECT była istotnie większa w porównaniu z objętością oszacowaną w badaniu USG w grupach badanych i kontrolnych, palaczy i osób niepalących. Autorzy nie wykazali istnienia znamiennej korelacji pomiędzy poziomem wychwyty jodu a objętością wola ocenianą za pomocą badania USG połączonym ze scyntyografią ^{131}I .

Wnioski: Nie zaobserwowano istotnych różnic dotyczących średnich objętości tarczycy pomiędzy palaczami a osobami niepalącymi, co może sugerować brak działania wolotwórczego dymu tytoniowego lub wskazywać na potencjalne działanie wolotwórcze w grupie badanej, które nie było wystarczające istotne. (*Endokrynol Pol* 2009; 60 (6): 437–442)

Słowa kluczowe: wole, tarczycza, USG, SPECT



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Introduction

Enlargement of the thyroid glands is called goiter (volume above 18 ml in females and above 25 ml in males). The cause of goiter is most often long-term deficiency of iodine in the diet, but another etiopathogenesis might also occur, for example autoimmunological background. Certain periods of life also predispose to goiter (for example puberty) and certain states (for example pregnancy and state of physiologic lactation). Increased demand for thyroid hormones is observed during these times.

Goitryne (1,5-vinyl-2-tioxalidone) located in some vegetables, for example Brussels sprouts, radishes, spinach, and soya beans, is found in the group of goitrogenic factors.

Environmental pollution also has some influence on goiter occurrence. Different inorganic compounds (tiocyanides, chlorides, nitrates) and organic compounds (phenols, carbohydrates, and others) possess goitrogenic characteristics. Ingredients of tobacco smoke like derivatives of resorcinol, flavonoids, hydroxypyridines, and particularly tiocyanides can have goitrogenic properties through competitive inhibition of iodine transport to thyroid cells and iodine organification reactions.

The aim of our study was the evaluation of goiter volume by ultrasonographic and radioisotopic methods together with the evaluation of nicotine (smoking) influence on thyroid volume with regard to the sex of the examined persons, and the relationship between iodine uptake and thyroid volume in smokers and non-smokers.

Material and methods

One hundred and sixty patients with Graves' disease in anamnesis were included in the study and were referred for diagnostic examinations from the outpatient clinic of endocrinology and the Department of Endocrinology and Diabetology of *Collegium Medicum* in Bydgoszcz. The patients were divided into two groups: A and B. Group A consisted of 50 patients (39 females, 11 males) with goiter, where thyroid volume was compared by US and scintigraphy (SPECT) with use of ^{131}I . Group B consisted of 50 patients (43 females, 7 males) with goiter, where thyroid volume was compared by US and scintigraphy (SPECT) with use of $^{99\text{m}}\text{Tc}$.

There were two control groups, A' and B'. Control group A' consisted of 30 patients (21 females, 9 males) with normal volume of thyroid gland in US and scintigraphy (SPECT) with use of ^{131}I . Control group B' consisted of 30 patients (23 females, 7 males) with regular volume of thyroid gland in US and scintigraphy (SPECT) with use of $^{99\text{m}}\text{Tc}$.

Subjects from the examined groups (A and B) and the control groups (A' and B') were divided in two sub-

groups — smokers (minimum 5 cigarettes per day) and non-smokers.

We had the approval of the Institutional Review Board and Local Committee of Ethics for our study.

All patients were examined by US and scintigraphy (SPECT) of the thyroid gland, with use of $^{99\text{m}}\text{Tc}$ or ^{131}I , and were evaluated according to iodine uptake. Ultrasonography was carried out with an ALOKA SSD 500, working in real time with a linear head of 7.5 MHz frequency.

Single positron emission computed tomography (SPECT) of the thyroid gland was performed with a single-headed gamma camera by Diacam, using a low-energy collimator of high resolution for SPECT examination with use of $^{99\text{m}}\text{Tc}$ (140,5 keV), and a high-energy collimator for SPECT examination with use of ^{131}I (364 keV).

Results

The patients from examined group A and control group A' were divided into two subgroups — smokers and non-smokers.

The thyroid volume measured in the ^{131}I -SPECT examination was significantly larger in comparison to the US examination in the examined and control groups in smokers and in non-smokers (Fig. 1).

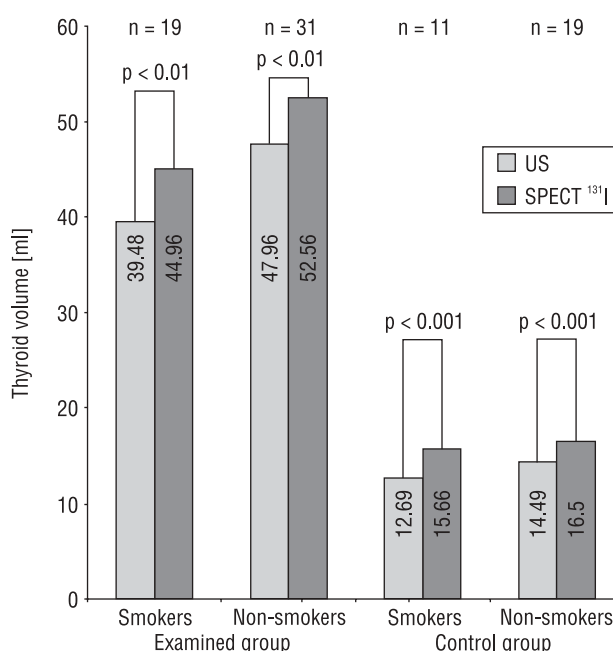


Figure 1. Comparison of thyroid volume measured by means of US and ^{131}I -SPECT in smokers and non-smokers (females and males)

Rycina 1. Porównanie objętości tarczycy mierzonej za pomocą USG i badania ^{131}I -SPECT u osób palących i niepalących (kobiety i mężczyźni)

Table I. Comparison of thyroid volume with US in smokers and non-smokers together with ¹³¹I-SPECT examination in smokers and non-smokers**Tabela I.** Porównanie objętości tarczycy za pomocą badania ultrasonograficznego u osób palących i niepalących z badaniem ¹³¹I-SPECT u osób palących i niepalących

	Sex	Smokers		Non-smokers		p	
		n	Average volume ± SD	n	Average volume ± SD		
Examined group	US	F+M	19	39.48 ± 26.16	31	47.66 ± 33.67	NS
		F	15	37.36 ± 27.4	24	47.61 ± 35.6	NS
		M	4	47.43 ± 18.83	7	47.84 ± 26	NS
	SPECT ¹³¹ I	F+M	19	44.96 ± 24.87	31	52.56 ± 31.01	NS
		F	15	42.95 ± 26.06	24	51.99 ± 32.42	NS
		M	4	52.47 ± 17.88	7	54.53 ± 25.47	NS
Control group	US	F+M	11	12.69 ± 3.61	19	14.49 ± 4.49	NS
		F	7	10.9 ± 1.76	14	13.99 ± 2.67	< 0,01
		M	4	15.83 ± 3.87	5	15.9 ± 4.83	NS
	SPECT ¹³¹ I	F+M	11	15.66 ± 3.38	19	16.5 ± 2.75	NS
		F	7	13.63 ± 2.56	14	15.84 ± 2.22	NS
		M	4	19.19 ± 4.74	5	18.27 ± 3.22	NS

Table II. Correlation of goiter volume evaluated by US and ¹³¹I-SPECT with iodine uptake level in examined and control groups**Tabela II.** Korelacja pomiędzy objętością wola oceniana za pomocą badania ultrasonograficznego i ¹³¹I-SPECT a poziomem jodochwytności w grupach badanej i kontrolnej

Parameter	Sex	Examined group		Control group	
		r	p	r	p
US	F + M	0.144	NS	0.333	NS
	F	0.209	NS	0.303	NS
	M	-0.253	NS	0.576	NS
SPECT ¹³¹ I	F + M	0.171	NS	0.203	NS
	F	0.236	NS	0.24	NS
	M	-0.189	NS	0.382	NS

The results of measurements of thyroid glands in the US examination in smokers and non-smokers together with the ¹³¹I-SPECT examination in smokers and non-smokers are presented in Table I.

Statistically significant correlations between the level of iodine uptake and goiter volume evaluated by US examination and scintigraphy (SPECT) with use of ¹³¹I (Table II) were not observed.

The division of goiter volume and ¹³¹I uptake concerning smokers and non-smokers is presented in Tables III–V.

Table III. Small goiter: F = 18–40 ml; M = 25–40 ml**Tabela III.** Wole małe: K = 18–40 ml; M = 25–40 ml

Small goiter	Smokers	Non-smokers	p
Females (n = 23)	31.6% (n = 11)	48.65% (n = 12)	< 0.001
Males (n = 5)	30.6% (n = 1)	48.03% (n = 4)	NS
F+M (n = 28)	31.51% (n = 12)	48.5% (n = 17)	< 0.001

Table IV. Large goiter: F i M = 40–100 ml**Tabela IV.** Wole duże: K i M = 40–100 ml

Large goiter	Smokers	Non-smokers	p
Females (n = 14)	46.64% (n = 3)	53.27% (n = 11)	NS
Males (n = 5)	48.46% (n = 3)	37.35% (n = 2)	NS
F+M (n = 19)	47.55% (n = 6)	50.82% (n = 13)	NS

Patients from examined group B and control group B' were divided into two subgroups – smokers and non-smokers.

The thyroid volume measured in the ^{99m}Tc-SPECT examination was significantly larger compared to that

Table V. Enormous goiter: F and M > 100 ml

Tabela V. Wole olbrzymie: K i M > 100 ml

Enormous goiter	Smokers	Non-smokers	p
Females (n = 2)	21.7%	62.3%	NS
Males (n = 1)	–	30.3%	–
F + M (n = 3)	21.7%	46.3%	NS

measured by US in the examined and control groups in smokers and non-smokers (Fig. 2).

Results of measurements of thyroid volume by US in smokers and non-smokers together with ^{99m}Tc -SPECT examination in smokers and non-smokers are shown in Table VI.

Discussion

Ultrasonography is the most frequently used method to evaluate thyroid volume in routine clinical examinations. This examination has many advantages: the method is available, inexpensive, repeatable, and non-invasive [1–3]. The US method could be performed in every patient, in certain circumstances, although, for example in cases of retrosternal goiter, other methods of imaging including scintigraphy are necessarily required.

There are numerous reports in scientific papers available in which the use of scintigraphy, especially SPECT, is considered valuable in thyroid size evaluation. Zaidi [4]

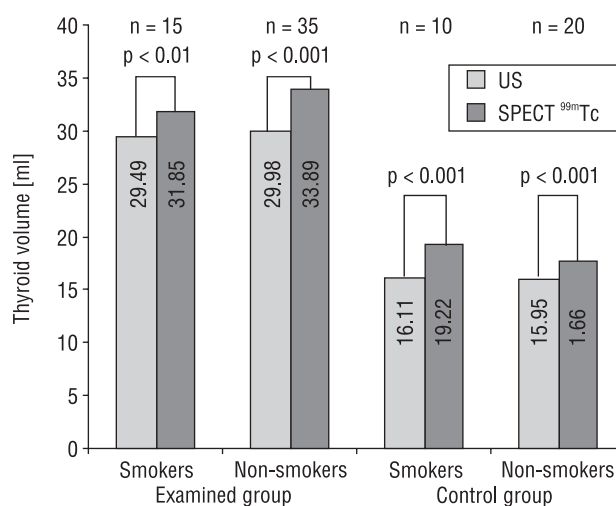


Figure 2. Comparison of thyroid volume measured with US and ^{99m}Tc -SPECT in smokers and non-smokers (females and males)

Rycina 2. Porównanie objętości tarczycy mierzonej za pomocą USG i badania ^{99m}Tc -SPECT u osób palących i niepalących (kobiety i mężczyźni)

concludes in his study that single photon emission computed tomography is a much better and much more sensitive examination of thyroid gland than planar scintigraphy [3].

In the aforementioned study, thyroid volume was compared with the use of US and scintigraphy (SPECT) with ^{131}I in the first group of patients (n = 50) and in the control group (n = 30), and ^{99m}Tc in the second group of patients (n = 50) and in the control group (n = 30).

Table VI. Comparison of thyroid volume with US in smokers and non-smokers together with ^{99m}Tc -SPECT examination in smokers and non-smokers

Tabela VI. Porównanie objętości tarczycy za pomocą badania ultrasonograficznego u osób palących i niepalących z badaniem ^{99m}Tc -SPECT u osób palących i niepalących

	Sex	Smokers		Non-smokers		p	
		n	Average volume \pm SD	n	Average volume \pm SD		
Examined group	US	F + M	15	29.49 \pm 9.63	35	29.98 \pm 11.03	NS
		F	12	29.83 \pm 10.72	31	29.16 \pm 10.99	NS
		M	3	28.11 \pm 1.26	4	36.36 \pm 9.11	NS
	SPECT ^{99m}Tc	F + M	15	31.85 \pm 8.56	35	33.89 \pm 11.2	NS
		F	12	32.12 \pm 9.5	31	32.8 \pm 10.6	NS
		M	3	30.76 \pm 1.96	4	42.28 \pm 12.1	NS
Control group	US	F + M	10	16.11 \pm 4.92	20	15.95 \pm 3.55	NS
		F	5	11.9 \pm 3.54	18	15.12 \pm 2.66	NS
		M	5	20.32 \pm 0.75	2	23.44 \pm 0.31	<0,001
	SPECT ^{99m}Tc	F + M	10	19.22 \pm 4.62	20	17.66 \pm 2.78	NS
		F	5	15.05 \pm 2.71	18	16.92 \pm 1.75	NS
		M	5	23.39 \pm 0.78	2	24.34 \pm 0.22	NS

In both examined groups, similar relativeness was observed. The average volume of goiter was 44.55 ml in US and 49.67 ml in SPECT, in the first group of patients (^{131}I). However, thyroid volume was 13.83 ml *v.* 16.19 ml in the control group.

In the second group of patients, ($^{99\text{m}}\text{Tc}$) differences of average measurements of goiter volume between US and SPECT were 3.44 ml (29.83 ml *v.* 33.27 ml); however, in the control group it was 2.18 ml (16 ml *v.* 18.18 ml). The differences of measurements reached significance levels.

In the past 20 years a number of studies have covered the influence of smoking on the thyroid gland. The results of many publications indicate a potential, complex influence of nicotine on the size and activity of the thyroid gland. Smoking might have a stimulating influence on the thyroid gland in healthy people, but the influence of nicotine in patients with subclinical or evident hypothyroidism might be inhibiting.

Evaluation of the influence of smoking on goiter development is one of the analyzed issues. Various opinions on the possible goitrogenic activity of tobacco smoke are concluded in available publications.

Most of the recent studies indicate that smoking might influence an increase in thyroid volume and goiter development [5–8]. Smoking might even be an independent risk factor of goiter development, according to some scientists [9, 10]. More frequently, goiter, evaluated by physical examination as with US, was noted in smokers in comparison to non-smokers in various published research [7, 9, 11–14]. The goitrogenic influence of smoking tobacco was confirmed by Christensen et al. in their research [11]. They observed goiter in 15% of examined smokers in palpation. However, goiter was observed only in 9% of non-smokers. Larger volumes of thyroid and increased frequency of goiter among smokers were observed especially in areas with iodine deficit. The aforementioned observations suggest synergic impact of smoking and insufficient iodine intake. The possible influence of nicotine on changes in the echogenicity of the thyroid gland was indicated in several scientific reports, because more frequent multinodular goiter was observed among smokers [15, 16].

The goitrogenic mechanism of cigarettes is not yet explained. It is assumed that the ingredients of tobacco smoke, such as derivatives of resorcinol, flavonoids, hydroxypyridines, and especially thiocyanides, might inhibit iodine transport to thyroid cells and the reaction of iodine organification. Such substances might also enable iodine to go out of the thyroid gland [12, 17, 18]. On the basis of experiments, thiocyanides were observed to be the most goitrogenic of all ingredients of tobacco smoke [18]. The results of some research indicate possible goitrogenic activity of thiocyanides, in which a posi-

ve correlation between thiocyanides concentration in blood serum and volume of thyroid gland was shown [6].

Some scientists also suggest a different, indirect goitrogenic mechanism of nicotine, like possible activation of the sympathetic nervous system [12, 13] and the stimulation of thyroid hormones output related to that.

On the other hand, there are some reports indicating a lack of influence of smoking on the volume of the thyroid gland [19–21]. Gomez et al. [19] carried out a study on 268 patients (134 females and 134 males) without thyroid disease in anamnesis, in which they did not observe any influence of smoking cigarettes on thyroid volume. In addition, Fatma et al. [20], after the examination of 500 patients, did not conclude statistically essential differences in thyroid volume in smokers and non-smokers. The more common abnormalities of the echogenic structure of the thyroid gland in smokers were also not observed in several other studies [20, 22].

Mentioned relativeness was observed in areas of sufficient iodine intake, where the research was carried out by Gomez [19] and Fatma [20].

In the aforementioned study, statistically significant differences in thyroid volume were not observed between smokers and non-smokers, in the examined and control groups. The results were obtained in Poland, in the Kujawsko-Pomorskie region, where this research study was carried out. This region is connected to the Wielkopolskie region, where despite iodine prophylaxis introduced in 1996, permanent iodine deficit is observed [23].

The results obtained by Georgiadis et al. [22] were notable because the authors proved goitrogenic activity of smoking tobacco only in patients with positive family anamnesis regarding goiter. The primarily observed differences in thyroid volume between smokers and non-smokers disappeared after excluding persons with first level relatives having goiter of analysis.

In the aforementioned study, no significant correlation between thyroid volume and iodine uptake was observed in patients from the examined and control groups. The size of thyroid gland did not influence the level of iodine uptake significantly.

No scientific papers evaluating the correlation between thyroid volume and iodine uptake in areas of satisfactory iodine intake were found in the literature.

The influence of nicotine on iodine uptake in patients with goiter was also evaluated in this study. Lower than average radioiodine uptake was observed in the group of patients with small goiter (≤ 40 ml) and cigarette smoking, in comparison with the non-smokers (31.51% *v.* 48.5%; $p < 0,001$).

The obtained results might be explained by the probable inhibiting influence of cigarette smoking on iodine uptake by thyroid gland cells, as suggested by au-

thors of some recently published research [12, 18]. A vital role in this process is connected to the thiocyanides present in tobacco smoke [18]. Antithyroid activity of other ingredients of tobacco smoke cannot be excluded.

Conclusions

1. Measurement of thyroid volume in the examined group and the control group was significantly increased in SPECT examination with use of ^{131}I and $^{99\text{m}}\text{Tc}$, according to US examination.
2. Significant differences in average values of thyroid volume between smokers and non-smokers were not observed, which might suggest lack of goitrogenic activity of tobacco smoke or indicate that the potential goitrogenic influence was not significant enough in the examined groups.
3. The size of thyroid gland did not significantly influence the level of iodine uptake. Lower than average uptake of iodine ^{131}I was observed in smokers with small goiter (≤ 40 ml) in comparison with non-smokers, which might suggest probable inhibiting influence of tobacco smoke on iodine uptake by thyroid gland cells.

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