Coll. Antropol. **28** (2004) 1: 287–291
UCD 612.44-087:616.441-073
Original scientific paper

Ultrasonographic Measurement of the Thyroid Volume

Gordana Ivanac[1], Berislav Rožman[2], Franjo Škreb[2], Boris Brkljačić[1] and Ladislav Pavić[1]

[1] Department of Diagnostic and Interventional Radiology, University Hospital »Dubrava«, Zagreb, Croatia
[2] Department of Nuclear Medicine, University Hospital »Dubrava«, Zagreb, Croatia

A B S T R A C T

According to the published data, endemic goiter was until recently, still present in some regions in Croatia. In this study the thyroid volume in grown-up, student population was measured. It was also analyzed which of the several traditional physiological attributes (body weight, body height, and body surface area (BSA)) were best correlated with the thyroid volume. Fifty one randomly selected female students from University of Zagreb Medical School were studied. Mean age of our subjects was 22 (range 20–38). All of them were healthy and with normal thyroid hormonal status. The mean thyroid volume was 10.68±2.83 mL (range 5.71–17.09 mL). The results show that thyroid volume was best correlated with body height (r=0.37; p=0.001), followed with body surface area (r=0.28; p=0.017). The thyroid volume was found normal in all our subjects.

Key words: *iodine deficiency, thyroid volume, goiter, ultrasonography*

Introduction

Iodine is crucially important for normal thyroid function. Iodine enters the thyroid follicular cells as inorganic iodide and is transformed through a series of metabolic steps into the thyroid hormones thyroxine (T4) and triiodothyronine (T3). Major steps of the iodine metabolism include: 1) active iodide transport; 2) iodination of tyrosyl residues of thyroglobulin (Tg); 3) coupling of iodotyrosine molecules to form T3 and T4; 4) proteolysis of Tg, with release of free iodotyrosines and iodthyronines; 5) deiodination of iodotyrosines and reuse of liberated iodide and 6) deiodination of T4 to T3[1].

In adequate iodine metabolism, the thyroglobulin accumulation is sufficient to sustain normal thyroid function for two months without iodine uptake. In the situation of chronic iodine deficiency,

Received for publication September 1, 2003

mechanisms are activated to increase hormonogenesis. One of the basic changes is an elevated TSH (thyrotropin) secretion. Prolonged TSH elevation induces hypertrophy and hyperplasia of thyroid follicular cells, causing enlargement of the gland[1,2]. In the beginning there is a diffuse thyroid enlargement. This process is still reversible if adequate iodine uptake is reestablished. But if iodine deficiency continues, the process becomes irreversible, and nodular goiter develops.

According to the World Health Organization (WHO) – International Council for the Control of Iodine Deficiency Disorders criteria (ICCIDD), endemic goiter is present in some region if among the children of the age 6–12 more than 5% have goiter[3,4].

During 1950's goiter prevalence in Croatia varied from approximately 46% to 80% depending on the region[5–7]. Areas along the Adriatic coast were the only regions of the country, which were considered to be goiter free. After the obligatory iodination of household salt was legislated in 1953, the goiter prevalence in Croatia was reduced threefold over the next decade[5,6]. But at the beginning of the 1990's the prevalence of goiter among school children in Croatia raised again[8].

The studies today still indicate persistence of goiter in some parts of Croatia[9,10]. The results of thyroid volume measurement in 13-year old school children in Zagreb were similar to those in Germany, and almost two times higher compared to Sweden[9–12].

Except the influence on thyroid gland, iodine deficiency can adversely affect the overall health of an unborn, children and adults. The possible resultant disorders are known as iodine deficiency disorders (IDD)[4,13].

Material and Methods

We studied 51 randomly selected female students from the University of Zagreb Medical School. Mean age for our subjects was 22 (range 20–38). They have not taken any thyroid-specific medication. All of them were healthy and with normal thyroid hormonal status, (TSH 2.14±1.03 mU/L; FT3 5.65±0.54 pmol/L; FT4 14.23±3.12 pmol/L). TSH (normal range 0.47–4.68 mU/L), free T3 and free T4 (normal range 4.26–8.10 pmol/L; 10.00–28.20 pmol/L) were measured from serum sample using the Vitros Eci immunodiagnostic system (Ortho-Clinical Diagnostics, UK). The chemiluminescence method was used. For free T3 and free T4 a direct, labeled antibody, competitive immunoassay technique was used. For TSH immunometric technique was used.

Thyroid measurements were obtained using real-time Ultrasound scanner (LOGIQ 400 MD G.E. Medical Systems Milwaukee, WI, U.S.A.) with a 7.5 MHz, 50 mm linear transducer. Examinations were made in a supine position of the patient with maximum neck extension. Longitudinal and transverse scans were performed, to obtain length width and depth in centimeters, of each lobe and isthmus. The thyroid volume was calculated as a sum of lobe volumes and isthmus volume[9,10]. The lobe volume was calculated using the rotation ellipsoid model formula[14,15]: V_{Lobe} (ml) = $\pi/6$ × width of lobe (cm) × depth of lobe (cm) × length of lobe (cm). The isthmus volume was calculated using following formula: $V_{Isthmus}$ (ml) = $\pi/6$ × width of isthmus (cm) × depth of isthmus (cm) × length of isthmus (cm).

Thyroid volume was correlated to body weight (W), body height (H) and body surface area (BSA). BSA was calculated using a standard formula[16]: BSA (m^2) = W (kg) $^{0.425}$ × H (cm) $^{0.725}$ × 71,84 × 10^{-4}. Correlation analysis and analysis of variance (Statistica Version 5.0; Excel Microsoft) were used to test the results.

The same person performed all ultrasound measurements. Each dimension was measured three times, and the intra-ob-

TABLE 1
THYROID VOLUMES

	Left lobe volume (mL)	Right lobe volume (mL)	Isthmus volume (mL)	Total volume (mL)
Mean	4.22±1.29	5.46±1.68	1.01±0.31	10.68±2.83
Variability coefficient	30.52	30.74	30.54	26.54
Minimum value	2.05	2.72	0.45	5.71
Maximum value	6.96	9.42	2.34	17.09

server error was calculated for the left lobe: 6.46%; right lobe: 8.67%; and isthmus: 19.41%. Our intra-observer error was comparable to values in similar studies, and we believe it did not significantly influence the final results[17–19].

Results

Thyroid volumes for each lobe, isthmus and for the gland *in-toto* are presented in the Table 1. The mean total thyroid volume was 10.68±2.83 mL; and the maximum measured volume was 17.09 mL.

Thyroid volume was found to weakly, but statistically significantly, linear correlate to body height ($r=0.37$; $p<0.01$) and body surface area ($r=0.28$; $p<0.05$). There was no significant linear correlation between thyroid volume and body weight. All the results regarding thyroid volume correlation to body height, body surface area and body weight are presented in the Table 2.

TABLE 2
TOTAL THYROID VOLUME CORRELATION TO BODY WEIGHT, BODY HEIGHT AND BODY SURFACE AREA

	r^2	r	p
Height	0.14	0.37	0.001
Body surface area	0.08	0.28	0.017
Weight	0.05	0.23	0.056

Discussion

According to the published data, endemic goiter was until recently, still present in some regions in Croatia[5–11]. Further on, Ministry of Health of the Republic of Croatia passed a new legislation on obligatory household salt iodination in 1996, after it concluded that iodine deficiency was still a problem in some regions of Croatia even in 1990's[20].

Conversely to all these disturbing data on the issue of iodine deficiency in Croatia, surprisingly few contemporary studies regarding the issue are published. In the only study published after the new legislation on obligatory household salt iodination, urine iodine concentrations and thyroid volume were measured in primary school children in several regions in Croatia[21]. The authors found normal urine iodine concentrations in 41–70% of children, depending on region, and normal thyroid volume in all the subjects, as defined by the International Council for Control of Iodine Deficiency Disorders (ICCIDD). Up to our knowledge, no investigation was made on grown-up population.

In our research we wanted to study the thyroid volume in the grown-up, female student population in the county of Zagreb, a region in Croatia, which was in earlier investigations indicated as one with the iodine insufficiency problem[8–10]. We have chosen exclusively the female popu-

lation, because women have been shown to develop goiter significantly more often than men[22,23]. All our subjects were born and spent most of their lives in the county of Zagreb. We also wanted to investigate which of the several traditional physiological attributes (body weight, body height, and body surface area) were best correlated with the thyroid volume.

In all our subjects (mean 10.68mL ± 2.83mL) the thyroid volume was below recommended upper limit for adult population of 18 mL[24]. Further on, in all our subjects but two, thyroid volume was even below 16 mL that is a recommended upper limit for thyroid volume in children under 15 years of age[25].

We believe that our results support the notion that iodine insufficiency, in the county of Zagreb, and presumably in the whole country, has been substantially improved over the last decade. This especially after the recent state actions, on obligatory household salt iodization took place. Nevertheless, having in mind earlier findings and the relatively small number of our subjects, and also that our subjects were all young and educated, coupled with the fact that our study encompassed population from only one region in Croatia, further research in this important field is mandatory.

Our results also show that thyroid volume was best correlated with body height followed with body surface area (BSA). This is in accordance with previously published data[26–28].

Acknowledgements

We would like to thank Ž. Kušter from the Department of Nuclear Medicine, University Hospital »Dubrava« (Zagreb, Croatia) for providing statistical advice.

REFERENCES

1. SOLTER, M., Štitnjača: Sinteza hormona, sekrecija i metabolizam. In: VRHOVAC, B., I. BAKRAN, M. GRANIĆ, B. JAKŠIĆ, B. LABAR, B. VUCELIĆ (Eds.): Interna medicina. (Naprijed, Zagreb, 1991). — 2. GERBER, H., U. BURGI, H. J. PETER, H. E. WAGNER: The transformation of normal thyroid cells to goiter: the role of iodine depletion and repletion. (Schattauer, Stuttgart-New York, 1996). — 3. DELANGE, F., Iodine deficiency. In: BRAVERMAN, L. E., R. D. UTIGER (Eds.): WERNER and INGBAR'S: The thyroid: A fundamental and clinical text. (Lippincott – Raven, Philadelphia, 1996). — 4. WHO/UNICEF/ICCIDD: Indicators for assessing iodine deficiency disorders and their control programs through salt iodization. (WHO, Geneva, 1994). — 5. BUZINA, R., Am. J. Clin. Nutr., 23 (1970) 1085. — 6. MATOVINOVIĆ, J., Ann. Rev. Nutr., 3 (1983) 341. — 7. PREBEG, Ž., M. BAJZER, J. MATOVINOVIĆ, N. KOVAČIĆ, Higijena, 7 (1955) 307. — 8. KUSIĆ, Z., J. End. Inv., 12 (1989) 441. — 9. KUSIĆ, Z., N. ĐAKOVIĆ, A. KAIĆ-RAK, I. KARNER, S. LECHPAMMER, E. MESAROŠ-ŠIMUNČIĆ, I. PETROVIĆ, S. RONČEVIĆ, J. SMOJE, A. STANČIĆ, I. VALENT, F. DELANGE, J. Endocrinol. Invest., 19 (1996) 210. — 10. KUSIĆ, Z., S. LECHPAMMER, Coll. Antropol., 21 (1997) 499. — 11. MESAROŠ KANJSKI, E., I. KONTOŠIĆ, Z. KUSIĆ, A. KAIĆ-RAK, N. ĐAKOVIĆ, J. KUŠER, K. ANTONIĆ, Coll. Antropol., 23 (1999) 729. — 12. GUTEKUNST, R., H. SMOLAREK, W. WÄCHTER, P. C. SCRIBA, Dtsch. Med. Wschr., 110 (1985) 50. — 13. DELANGE, F., Thyroid, 4 (1994) 107. — 14. AGHINI-LOMBARDI, F., L. ANTONANGEZI, A. PINCHERA, F. LEOLI, T. RAGO, A. M. BARTOLOMEI, P. VITTI, J. Clin. Endocrinol. Metab., 82 (1997) 1136. — 15. KNUDSEN, N., B. BOLS, I. BÜLOW, T. JØRGENSEN, H. PERRILD, L. OVESEN, P. LAURBERG, Thyroid, 9 (1999) 1069. — 16. DUBOIS, D., E. F. DUBOIS, Archives of Internal Medicine, 17 (1916) 863. — 17. ÖZGEN, A., C. EROL, A. KAYA, M. N. ÖZMEN, D. AKATA, O. AKHAN, European Journal of Endocrinology, 140 (1999) 328. — 18. BÜRGI, H., L. PORTMANN, J. PODOBA, F. VERTONGEN, M. SRBECKY, European Journal of Endocrinology, 140 (1999) 104. — 19. HESS, S. Y., M. B. ZIMMERMANN, European Journal of Endocrinology, 142 (2000) 599. — 20. KUSIĆ, Z., Liječ. Vjesn., 118 (1996) 306. — 21. KUSIĆ, Z., S. LECHPAMMER, LJ. LUKINAC, I. PETROVIĆ, D. NÖTHING – HUS, J. Endocrinol. Invest., 22 (1999) 747. — 22. WANDERPUMP, M. P. J., W. M. G. TUNBRIDGE, The epidemiology of thyroid diseases. In: BRAVERMAN, L. E., R. D. UTIGER (Eds.): WERNER and INGBAR'S: The thyroid: A fundamental and clinical text. (Lippincott – Raven, Philadelphia, 1996). — 23. KOUAMÉ, P., G. BELLIS, A. TEBBI, M. GAIMARD, I. DILUMBU, A. ASSOUAN, F. ROUX, G. MAYER, I. CHASTIN, N. DIARRA,

A. CHAVENTRE, Coll. Antropol., 22 (1998) 31. — 24. GUTEKUNST, R., W. BECKER, R. HEHRMANN, T. OLBRICHT, P. PFANNENSTIEL, Dtsch. Med. Wschr., 113 (1988) 1109. — 25. WHO/ICCIDD, Bull World Health Organ., 75 (1997) 95. — 26. BERGHOUT, A., W. M. WIERSINGA, N. J. SMITS, J. L. TOUBER, Clin. Endocrinol. (Oxf), 26 (1987) 273. — 27. WESCHE, M. F., W. M. WIERSINGA, N. J. SMITS, Clin. Endocrinol. (Oxf), 48 (1998) 701. — 28. XU, F., K. SULLIVAN, R. HOUSTON, J. ZHAO, W. MAY, G. MABERLY, European Journal of Endocrinology, 140 (1999) 498.

G Ivanac

Department of Diagnostic and Interventional Radiology, University Hospital »Dubrava«, Av. Gojka Šuška 6, 10000 Zagreb, Croatia
e-mail: gordana.augustan@zg.tel.hr

ULTRAZVUČNO MJERENJE VOLUMENA ŠTITNJAČE

S A Ž E T A K

Sukladno dosad objavljenim podacima, endemska gušavost još uvijek je prisutna u nekim dijelovima Hrvatske. U ovom istraživanju mjeren je volumen štitnjače u odrasloj populaciji studenata. Također je ispitano koji je od tradicionalnih fizioloških atributa (tjelesna težina, tjelesna visina, površina tijela) u najvećoj mjeri povezan s volumenom štitnjače. Ispitivanje je izvršeno na slučajno odabranom uzorku od 51 studentice s Medicinskog fakulteta Sveučilišta u Zagrebu. Srednja životna dob ispitanica bila je 22 godine (raspon 20–38). Sve ispitanice su bile zdrave i imale su normalnu razinu hormona štitnjače u krvi. Srednji izmjereni volumen štitnjače bio je 10.68±2.83 mL (raspon 5.71–17.09 mL). Rezultati pokazuju da je volumen štitnjače u najvećoj korelaciji s tjelesnom visinom (r=0.37; p=0.001), nakon čega slijedi površina tijela (r=0.28; p= 0.017). Kod svih ispitanica nađene su normalne vrijednosti volumena štitnjače.