# Research methodology of radioiodine uptake test

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## Summary

One of the commonly performed studies of thyroid function is the measurement of radioiodine uptake prior to radioiodine $^{131}$I therapy. Treatment using radioisotopes found recognition among many clinicians from all over the world. Therapy with $^{131}$I is successfully used in the reduction of non-toxic nodular goitres, in the treatment of hyperthyroidism in the course of Graves-Basedow disease, and in the treatment of toxic nodular goitres. Before the elective treatment, thyreostatics and other iodine-containing substances should be withdrawn, as they could affect the results of the radioiodine uptake test by inhibiting iodide accumulation in the parenchyma of an active thyroid.

**Key words: radioiodine uptake • radioactive iodine • therapeutic dose**

The most important challenges of science are headed by those connected directly with human condition, quality of life and existence. The progress that is made by contemporary medicine influences significantly our life expectancy. Despite enormous efforts undertaken by researchers from all over the world, including Poland, there are still many unanswered questions concerning successful treatment methods. The state-of-the-art medical appliances, progress in understanding detailed physiological processes and aetiological mechanisms, all contribute to the advancement in the treatment of particular diseases.

One of the most common endocrinopaties includes the diseases of the thyroid gland whose main function is to produce and secrete the following hormones to the blood: triiodothyronine (T3) and thyroxine (T4), with their important component – iodine.

The activity of the thyroid gland may be defined i.a. *in vitro*, on the basis of immunological studies, by marking the level of free hormones ($FT_4$, $FT_3$) and tumour markers (thyreoglobulin, calcitonin – hormone that may become a tumour marker in medullary carcinoma of the thyroid gland and in other metabolic disorders and endocrinological tumour syndromes) [1,2], as well as with the use of the radioisotopic method – the measurements of radioiodine uptake, performed to qualify the patient for potential radioiodine therapy due to thyroid disease.

The aim of the work was to present some basic information on the use of $^{131}$I in the diagnostic process and treatment of thyroid diseases.

## Physical Properties of $^{131}$I Radioiodine

Iodine $^{131}$I is produced in nuclear reactors, as a result of neutron activation of $^{125}$I in the course of decay of $\beta^-$ direct products of radiative uptake, as well as the decay of β-fragments of $^{235}$U uranium fission.

$^{131}$I emits β particles with an average energy of 182 keV and high-energy γ-radiation with an energy of 364 keV. It is characterised by quite a long period of half life, amounting to 8.02 days. Despite all those negative physical properties, this is a routinely applied radiomarker in the diagnostic work-up of thyroid gland function, due to the high quality of scintigraphic images obtained with it.

It is available as an oral sodium iodide, water solution or a capsule [3].

Since late 1930's $^{131}$I has been the first radiopharmaceutical used in the evaluation of function and structure of the thyroid gland [4]. Apart from iodine $^{131}$I, radioisotopic diagnostic work-up employs also $^{123}$I, which is characterized by a 13-hour half life and the energy of emitted gamma quantum amounting to 159 MeV. Its additional advantage is that it does not emit β particles [5,6].

## Radioactive Iodine Uptake Test (RIU test)

### Indications for the performance of the test

Treatment of hyperthyroidism with radioactive iodine $^{131}$I is safe and effective. The therapy uses β radiation which destroys thyroid cells which combine iodine [7]. Iodine therapy is associated with a high rate of recovery, defined as relief of hyperthyroidism symptoms and achievement of euthyroidism or hypothyroidism [8].

The test of iodine uptake is applied to treat hyperthyroidism being a part of Graves-Basedow disease, to treat nodular toxic goitre, and to reduce the volume of nontoxic nodular goitre [9,10], to establish the cause of congenital hypothyroidism (ectopy, hipoplasia, aplasia), as well as to help to diagnose the subacute thyroiditis of de Quervain type, and, in individuals after strumectomy of the thyroid gland, to find metastatic foci and to determine the amount of the remaining thyroid tissue following surgical procedure [11].

### Patient's preparation

Before the treatment with radioactive iodine $^{131}I$, the clinicians should:
- establish the clinical diagnosis and thyroid function by marking TSH and $FT_4$ level,
- withdraw tyreostatics and iodine-containing preparations,
- measure iodine uptake and evaluate the volume of thyroid gland/nodes with USG. Carry out FNAB of the nodular lesions,
- exclude pregnancy in women of reproductive age.

The above mentioned clinical information may significantly influence final results of the iodine uptake test, and thus the therapeutic iodine dose.

### The procedure of the RIU test

The analysis of radioiodine uptake belongs to thyroid function tests [12]. The RIU test shows what percentage of radioactive iodine $^{131}I$ of known activity (2–4 MBq), administered orally, accumulates in the thyroid gland in a defined time. This test is performed after 18–24 hours from the moment of administration of a diagnostic capsule including radioactive iodine. Some centres of nuclear medicine prefer an additional measurement in the $4^{th}$–$6^{th}$ hour [13]. The examination is performed with a distance of 25–30 cm between the neck and the surface of the collimator, so that the central axis is passing in half way from the thyroid cartilage and the zygomatic notch of the sternum.

RIU [13] is calculated on the basis of the following formula:

$$RIU = \frac{C_N\,[\mathrm{cpm}] - B_N\,[\mathrm{cpm}]}{C_S\,[\mathrm{cpm}] - B\,[\mathrm{cpm}]} \times 100\% \quad (1)$$

with $C_N$ – counts from the neck, $B_N$ – background from the neck, $C_S$ – counts from the sample, B – background.

## Iodine Uptake in Some Chosen Diseases of the Thyroid Gland

Treatment of hyperthyroidism with radioactive iodine is simple, cheap, and connected with a low risk of side effects [14]. The therapy aims at controlling hyperthyroidism [15] and reducing the volume of the gland.

Radioactive iodine is administered orally [16] in the doses with activity of 3.7–5.5 MBq/1 g of thyroid tissue, for 100% uptake within 24 hours. The oral dose is established with the following formula [17,18]:

$$Dose_{Therapeutic} = \frac{weight[g] \times A/g_{thyroidtissue}[\mu Ci/g]}{T_{24}[\%] \times 10} \quad (2)$$

When analysing the equation we may notice that the therapeutic dose depends on the weight of the thyroid gland, the proportionate iodine uptake after 24 hours and therapeutic activity per one gram of the thyroid tissue.

Graves-Basedow disease (GB), with its autoimmunological background, is a genetically-determined disease, characterised by an overproduction of hormones of the thyroid gland, i.e. thyroxine or triiodothyronine [19]. It manifests itself by a toxic goitre or a diffuse nodule accompanied by a potential ophthalmopathy or dermopathy [20]. Physical examination may reveal i.a. body mass loss and hyperexcitability [21]. In patients with suspected or diagnosed GB, the scintigraphic examination of the thyroid shows a bilobed, enlarged gland, with an equal marker accumulation in both thyroidal lobes. According to Nordyk et al. [22], $RIU_{24h}$ ranges from 30–100%. In 70% of patients, a single dosage regimen leads to euthyreosis within 3 months, and the gland itself may decrease in size by 50–60% [16]. However, the sequela of the radioiodine treatment may be ophthalmopathy [23,24] and the aforementioned hypothyroidism, which may appear after a few years from the administration of the $^{131}I$ therapeutic dose.

Contrary to the GB disease, the toxic goitre is most frequent in the regions of iodine insufficiency. It is characterised by an enlarged thyroid gland, with its normal function and a normal function of the hypothalamus-pituitary-thyroid axis. Medicine distinguishes two types of goitres: parenchymatous and nodular one. It may become apparent in every age. Goitre is a consequence of a long-term activation of the thyroid gland by TSH. The parenchymatous goitre is an enlarged thyroid gland, while the nodular goitre involves the presence of one or a few nodules in the projection of the gland. On scintigraphic examination, the toxic goitre can be identified as an enlarged thyroid gland with a regular (parenchymatous goitre) or irregular (nodular goitre) accumulation of the radiopharmaceutical, with warm, hot or cold regions. Cold nodules found on examination constitute an indication for FNAB and for cytologic evaluation.

## Conclusions

Radioisotopic diagnostic examinations of the thyroid gland, due to their uninvasiveness, are still an indispensable diagnostic method useful in patient's qualification for radioiodine therapy in the era of such imaging methods as the USG or X-ray. Their advantage consists in their ability to register an active parenchyma of the thyroid gland and to evaluate the function of this gland.

## References:


1. Harrison TR: Harrison's principles of internal medicine. 2005; 2105–8
2. Hayes AA, Akre CM, Gorman CA: Iodine-131treatment of Graves' disease using modified early iodine-131 uptake measurements in therapy dose calculations. J Nucl Med, 1990; 31(4): 519–22
3. Robins RJ, Schlumberger MJ: The evolving role of $^{131}I$ for the treatment of differentiated thyroid carcinoma. J Nucl Med, 2005; 46: S28–37
4. Chapman EM: History of discovery and early use of radioactive iodine. JAMA, 1983; 15: 2042–44

5. Paras P, Hamilton DR, Evans C et al: Iodine-123 assay using a radionuclide calibrator. Int J Nucl Med Biol, 1983; 10(2–3): 111–15
6. Robertson JS, Verhasselt M, Wahner HW: Use of 123I for thyroid uptake measurements and depression of 131I thyroid uptakes by incomplete dissolution of capsule filler. J Nucl Med, 1974; 15(9): 770–74
7. Łącka K, Czyżyk A: Leczenie nadczynności tarczycy. Farm Współ, 2008; 1: 69–78 [in Polish]
8. Jastrzębska H, Gietka-Czernel M et al: Leczenie radiojodem nadczynności tarczycy u dzieci z chorobą Gravesa-Basedowa. Endokrynol Pol, 2003; 1(54): 23–30 [in Polish]
9. Jastrzębska H, Gietka-Czernel M, Zgliczyński S: Standardy leczenia radiojodem łagodnych schorzeń tarczycy. Endokrynol Pol, 2003; 54(2): 187–94
10. Erikston D et al: Treatment of patients with toxic multinodular goiter. Thyroid, 1998; 8: 277–82
11. Łącka K: Choroby tarczycy. Wydawnictwo Lekarskie PZWL, 1997 [in Polish]
12. Levy BS, Ashburn W: Thyroid-uptake studies using $^{132}$I. J Nucl Med, 1969; 10(6): 286–89
13. Balon HR, Silberstein EB et al: Society of Nuclear Medicine Procedure Guidelines for Thyroid Uptake Measurements, 2006
14. Berg G, Michanek A et al: Clinical outcome of radioiodine treatment of hyperthyroidism: a follow-up study. J Intern Med, 1996; 239: 165–71
15. Wartofsky L et al: Differences and similarities in the treatment of diffuse goiter in Europe and the United States. Exp Clin Endokrinology, 1991; 97: 243–51
16. Nygaard B, Hegedus L et al: Influence of compensated radioiodine therapy on thyroid volume and incidence of hyperthyroidism in Graves'disease. J Intern Med, 1995; 238: 491–97
17. Beierwaltes WH: The treatment of hyperthyroidism with iodine-131. Sem Nucl Med, 1978; 8: 95–103
18. Hayes AA, Akre CM, Gorman CA: Iodine-131 treatment of Grave's disease using modified early iodine-131 uptake measurements in therapy dose calculations. J Nucl Med, 1990: 31: 519–22
19. Reid JR, Wheeler SF: Hyperthyroidism: diagnosis and treatment. Am Fam Physican, 2005; 72: 623–30
20. Tomer Y, Davies TF: Infection, thyroid disease, and autoimmunity. Endocrine Rev, 1993; 1: 107–20
21. Prabhakar BS, Bahn RS, Smith TJ: Current perspective on the pathogenesis of Grave's disease and ophthalmopathy. Endocrine Rev, 2003; 24: 802–35
22. Nordyke NA, Gilbert FI: Optimal iodine-131 dose for eliminating hyperthyroidism in Graves Disease. J Nucl Med, 1991; 32: 411–16
23. Bartalena L, Marcocci C, Bogazzi F et al: Relation between therapy for hyperthyroidism and the course of Graves' ophthalmopathy. N Engl J Med, 1998; 228: 73–78
24. Kalmann R, Mourits MP: Diabetes mellitus: a risk in factor in patients with Graves' orbitopathy. Br J Ophthalmol, 1999; 83: 463–65