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ORIGINAL PAPER

# Principles of safety use of radioiodine in the treatment of well-differentiated thyroid carcinoma (DTC)

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**Abstract.** The post-operative radioiodine treatment of patients with well-differentiated thyroid carcinoma decreases cancer death, tumor recurrences and development of distant metastases. The recommended dose of $^{131}$I ranging from 1.1 to 11.1 GBq. Because these doses are much higher than the permissible dose of $^{131}$I for outpatients (800 MBq), all patients are treated during hospitalization. In the Department of Endocrinology and Radioisotope Therapy from 1998 to the end of June 2008 694 patients have received at least one dose of $^{131}$I for DTC. Nowadays, cumulative yearly dose exceed 200 GBq. High doses of $^{131}$I may cause radiation exposure to personnel and environmental hazard. The last mentioned is caused mainly by radioactive liquid wastes with comprise washing water and excreta (urine, feces). In order to minimize this hazard radioactive liquid waste from isolated Radioisotope Therapy Unit are discharged into internal hospital sewage system and stored in 4 containers until $^{131}$I concentration decreases up to the recommended level.

**Key words:** well-differentiated thyroid carcinoma • radioiodine therapy • radioactive wastes

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## Introduction

Well-differentiated thyroid carcinoma (DTC) is the most common thyroid malignancy – it accounts for almost 90% of thyroid cancers [4, 9, 11]. Management of DTC contains surgery (total thyroidectomy for most of patients) followed by an ablative dose of $^{131}$I [4, 5, 8–12]. The aim of radioiodine treatment is the post-operative ablation of residual functional thyroid tissue. Post-operative $^{131}$I therapy can also destroy occult microscopic carcinoma and thus decrease the long-term risk of the recurrence and mortality rate [4, 9–12]. Therapeutic activity of $^{131}$I ranges from 1.1 to 11.1 GBq [5, 8–12]. Nowadays, the recommended standard dose for thyroid ablation ranging from 2.2 to 3.7 GBq [5]. Our results confirm those previously reported [6, 10] that six months after initial radioiodine therapy approximately 80% of patients have no evidence of thyroid tissue. The rest require the next dose of $^{131}$I – therapeutic procedure is repeated at 6–12 months intervals until there is no scan evidence of functioning thyroid tissue and the thyroglobulin (Tg) levels are undetectable [4, 5, 10, 11].

Higher ablative doses ranging from 3.7 GBq to 7.4 GBq are used for high-risk patients, particularly those with incomplete resection of the primary tumor

**Table 1.** Patients undergone $^{131}$I ablation (2005 – June 2008)

| | 2005 | 2006 | 2007 | I–VI 2008 |
|---|---|---|---|---|
| No. of patients | 121 | 78 | 97 | 63 |
| First therapy patients | 91 | 63 | 78 | 46 |
| No. of $^{131}$I doses* | 124 | 79 | 103 | 64 |
| $^{131}$I activity range | 2.01–3.43 GBq | 1.6–2.92 GBq | 1.84–3.27 GBq | 1.82–4.29 GBq |

* The reason for differences between number of patients and number of $^{131}$I doses is the next administration of radioiodine in the cause of incomplete thyroid ablation.

or with invasive primary tumor [4, 10]. Patients with metastatic disease are often treated with repeated therapeutic doses of $^{131}$I – from 2.8 GBq for diffuse pulmonary metastases [4, 8] up to 7.4 GBq (or more) for bone metastases [2, 4, 8–11].

The aims of our study were: 1) to present a scheme of radioiodine administration in our Institute; 2) to calculate the administrated activities of radioiodine and 3) to assess the radiation environmental hazard and the method of its reducing.

## Clinical protocol

In the Department of Endocrinology and Radioisotope Therapy from 1998 to the end of June 2008 694 patients have received at least one dose of $^{131}$I for DTC. In regard to the number of patients our Department is the second largest in Poland (Table 1).

According to the Polish national regulations, the maximum permissible dose of $^{131}$I for outpatients is 800 MBq. Because higher doses of $^{131}$I are required for effective ablation, the treatment is performed during 5 days of hospitalization. All patients are prepared in the same way for the administration of radioiodine. $^{131}$I ablation therapy is usually performed 4–6 weeks after surgery [4, 5, 9]. Alternatively, $^{131}$I is given after withdrawal of thyroxine for 3 to 4 weeks [5]. The patients are admitted to Radioisotope Therapy Unit. This special part of our Institute has 3 isolated rooms with 8 beds. Before $^{131}$I administration, oral and written information about treatment procedure and radiation safety is given to the patients. Because of the consequent exposure of the fetus to a high dose of radioactivity, $^{131}$I is contraindicated in pregnancy. Women should not breast-feed.

On the first two days TSH, Tg and AbTg (anti-Tg antibodies) levels are measured and thyroid uptake test is performed. If 24 h uptake is below 20% and TSH serum concentration > 30 mIU/l [4, 5, 8–10], the patients receive an ablation therapy. 72 h after radioiodine administration, a whole-body scan (WBS) is performed [5, 10] (Table 2).

Then, the patients are discharged from the hospital and started on thyroid replacement therapy. They are requested to avoid close contact with children and pregnant women for a few days.

**Table 2.** Therapeutic protocol

| | TSH, Tg, AbTg | $^{131}$I ↓ | | | WBS |
|---|---|---|---|---|---|
| days | 1 | 2 | 3 | 4 | 5 |
| | 24 h uptake test → | | | | |

## Radiation safety

After administration of $^{131}$I, radiation is emitted from radionuclide in the patient and radioiodine is secreted in body fluids such as sweat or saliva and excreted into urine and feces causing external exposure of personnel to radiation and environmental hazard [1, 3, 7]. The last-mentioned is caused mainly by radioactive liquid waste which comprise washing water and excreta (urine, feces). In order to minimize this hazard radioactive liquid waste from all 3 rooms are discharged into an internal hospital sewage system and stored in 4 containers which are located outside of the hospital building. These containers have 1.57 m$^3$ capacity (each of them) and are filled one after another during 6–10 weeks. This means that the radioactivity is stored in each container by a minimum of 24 weeks (20-fold longer than physical half-life of $^{131}$I).

Irrespective of the time, $^{131}$I concentration in the wastes is estimated. Every time five radioactive liquid samples, each of 2 litres, are collected from the storage waste containers. Samples are measured in the laboratory using a gamma-rays spectrometer with an HPGe detector (Canberra-Packard Ltd, USA). The spectrometer was calibrated for a 450 ml Marinelli beaker geometry. When the measured $^{131}$I concentration is below the maximal permissible level, the wastes are discharged into the public sewerage system. When it is above the limit#, the wastes are stored until $^{131}$I concentration decreases up to the recommended level.

Moreover, external dose rate near containers are measured with a portable dose rate monitor fieldSPEC-N (Souther Scientific Ltd, UK). The external dose rate values range from 80 nGy/h to 120 nGy/h little above the background.

## Conclusions

Post-operative thyroid ablation with radioiodine is a simple and effective therapy of well-differentiated thyroid carcinoma. Monitoring of radioactive liquid wastes allows to avoid an environmental hazard despite the administration of high-doses of $^{131}$I.

# Regulation of the Council of Ministers of 3 December 2002 on radioactive waste and spent nuclear fuel (O.J. No. 230 Item 1925).

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