Harmonization of radiation protection, imaging and dosimetry practices of I-131 therapy in Finland

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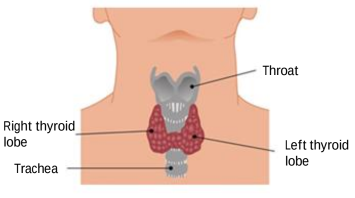
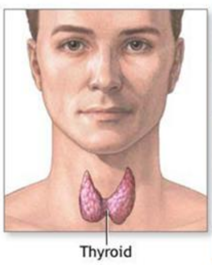
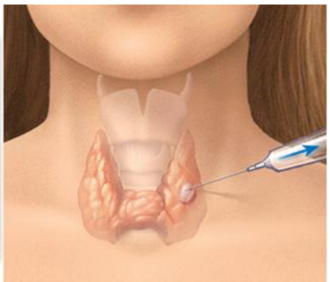
Radioiodine therapy for thyroid cancer

- Radioiodine therapy is globally the most common radionuclide treatment
- It is used to treat patients with residual thyroid cancer and its metastases after total or subtotal thyroidectomy
- In this therapy ^{131}I isotope is utilized. The activities used vary between 1.11 – 5.5 GBq.
- Thyroid gland takes up most (≈ 25-50 %) of the intaken iodine
- In Finland about 450 new thyroid cancer cases show up annually and in 2015 about 550 cancer therapy capsules were delivered into Finnish hospitals
- In this therapy, the highest activities in the hospital environment are used

  → ***requires careful during and after therapy radiation protection procedures***





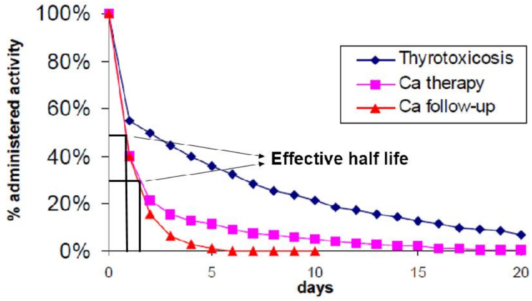


I-131 isotope

- Physical half-life: 8,02 d
- Beta energy: 606 keV (89%) → ablation effect
- Gamma energy: 364 keV (81%), → radiation for imaging
- Typically used activities:
  - Cancer therapy (ablation): 1,11 or 3,7 GBq
  - Hyperthyroidism: 100 – 800 MBq
  - Cancer follow-up: 185 MBq

37 MBq = 1 mCi

Metabolism of I-131



Effective (physical + biological) half life

- Cancer therapy: 11-12 h
- Hyperthyroidism: 111 – 136 h

[1] Meredith WJ, Massey JB. Fundamental Physics of Radiology; 420–3, 1977.
[2] R Ravichandran et al. Indian J Nucl Med.; 25(2): 49–52, 2010.

Some radioiodine activities during the years

- Local radiation protection training during years 2012-2016
- Winter-spring 2016: national survey for nuclear medicine departments
- Finnish Society for Oncology: Training days, 29.–30.1.2016, Turku
- Finnish Society of Nuclear Medicine, Annual meeting, 28.4.2016, Pori
- *In May 2016 Hanna Mäenpää established a national group to crease a guideline for thyroid carcinoma treatment, (also physicist Tenhunen and Noponen and Nikkinen (diagnostic radiology) participated)*
- *Several radiation isolation rooms were designed in Finnish hospitals during years 2016-2018 (in Lappeenranta, Jyväskylä and Kuopio)*
- Radiopharmacy days (isolation room design), 28.9.2016, Helsinki
- EANM 2017, 21-25.10.2017, Wien
- Finnish Society of Nuclear Medicine, Annual meeting, 16.5.2018, Kuopio
- STUK, Radiation protection days, 24.5.2018, Jyväskylä
- Finnish Society of Nuclear Medicine, Annual meeting, 15.5.2019, Lahti
- NSFS, Nordic IRPA conference, 12.6.2019, Helsinki

National radioiodine cancer therapy survey

- Survey was conducted in spring 2016 on the status of radiation protection and imaging practices related to ^{131}I cancer therapy in Finnish hospitals

- The questions dealt with dose measurement and delivery, patient in-hospital isolation and discharge and after-treatment imaging practices

- Answers were received from all Finnish 22 nuclear medicine departments operating in public hospitals (3 sites did not give ablation treatments)

Question categories:

- Measurement and dosage of capsule to patient *(who, where, how?)*
- Radiation isolation and discharge measurement (who, *where, when, how?)*
- Radiation protection instructions after the discharge of radiation isolation
- Patient imaging after ablation treatment *(when, how?)*

→ *Our aim is to harmonize practices*

Summary of Survey Results

- The results of the survey showed the need for standardization
- **Who** (radiographer, physician or physicist) does the capsule checking, gives the capsule to the patient or discharges the patient, **vary clearly** between the hospitals
- The activitity of capsule is checked using dose calibrator in all nuclear medicine departments expect in **one**
- The length of in-hospital radiation isolation period varies from **1 to 4 days**
- The dose rate level to terminate the radiation isolation ranges from **15 to 70 µSv/h** between different hospitals[1]
- 18 hospitals make the follow-up scans for the cancer patients, **one does not** scan the patients systematically
    - Interval between capsule dosage and follow-up scanning varies: **3-14 days**
    - 11 hospitals do SPECT- or SPECT/CT-imaging, 7 if required ja **2 not at all**

[1] measured with a gamma-beta radiation survey detector at 1 meter from a patient

Finnish Thyroid Cancer Group

- Hanna Mäenpää *(Department of Radionuclide Treatments, Helsinki University Hospital)* established in autumn 2016 Finnish Thyroid Cancer Group (about 60 national professionals)
- Aim: To create a national treatment guideline for thyroid cancer
- Also medical physicists Mikko Tenhunen and Tommi Noponen have participated in this group and wrote parts of the ”**Implementation of radioiodine therapy**” instruction, which included instructions for ”**Radiation protection during and after the therapy**” and ”**Nuclear medicine imaging**”
- **”Papillary and follicular thyroid carcinoma treatment guideline”** was published in **Terveyskylä.fi** in professional section in November 2017

TERVEYSKYLÄ.FI AMMATTILAISILLE

Papillary and follicular thyroid carcinoma treatment guideline 11 / 2017

Physicist club – Finnish Society of Nuclear Medicine

- Working group for giving recommendations to radiation protection, imaging and dosimetry of radioiodine cancer therapy patients
- The work has been carried out during the spring 2019
- **Recommendation for dosimetry of radioiodine therapy patients,** A. Sohlberg (Lahti) and M. Tenhunen (Helsinki)
- **Recommendation for the design of radiation isolation room for radioiodine therapy patients**, T. Noponen (Turku), J. Vuorela (Jyväskylä) and M. Tenhunen (Helsinki)
- **Dosimetry and radiation protection survey for hyperthyroidism therapy,** T. Laitinen (Kuopio) and T. Noponen (Turku)
- **National post-therapy radiation protection instruction for patient,** Noponen (Turku) ja Gröhn (Kuopio)
- Review and updates to ”**Radioiodine therapy discharge and contamination measurements”** instruction in **National thyroid carcinoma treatment guideline**, V. Tunninen, M. Tenhunen and Noponen
- Coordinators M. Hakulinen and Noponen
- Recommendations were published in **”Isotooppipäivät”** 15.5.2019

Dosimetry methods for radioiodine therapy of thyroid cancer

Antti Sohlberg and Mikko Tenhunen

- Bone marrow and lesion dosimetry models have been generally used
- However, currently there is no clinically well-proven routine method for dosimetric estimation of effects of generally used constant activities 1.1 tai 3.7 GBq
- Based on research, the dose of primary tumours and metastases calculated with the dosimetry methods can vary significantly between the patients
- With exceptionally high activities (> 7 GBq), the bone marrow dosimetry is recommended
- Further development of dosimetry techniques is important
- All future radioiodine research settings should include dosimetry part
- Currently dosimetry methods should be used with caution with radioiodine cancer therapy and they should be applied mainly for research purposes before more knowledge is gained for their clinical benefits

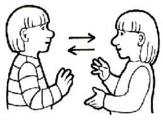
National recommendation for the design of radiation isolation room

Tommi Noponen, Juha Vuorela ja Mikko Tenhunen

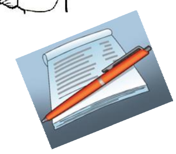
- General recommendations (suite for single person, outer corner of hospital building, first or top floor, own toilet and shower, entry room etc)
- Basic radiation safety equipments (labels, monitors, cleaning equipments for possible contamination etc)
- Calculation example for an annual radiation dose outside of the room from typical therapy
- Wall structures determined using tenth-value layer method

Design process

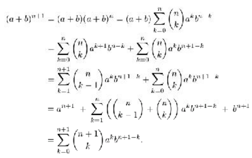
Ask from friends



Notes and publications

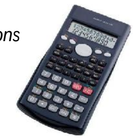


Modelling



Measurements

Calculations



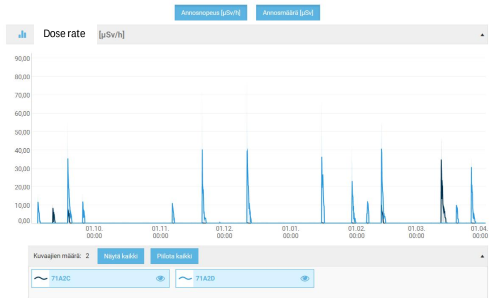
Determination of wall structure of radiation isolation room

	TVL	Lead	Concrete	Wall structure (from inside)
100 patients	$\log_{10}$ (34,1) = 1,53	0,36 TVL_1 = 4 mm	0,64 TVL_1 = 134 mm 0,53 TVL_2 = 74 mm	4 mm lead and ≈ 210 mm concrete
80 patients	$\log_{10}$ (34,1 x 0,8) = 1,44	0,27 TVL_1 = 3 mm	0,73 TVL_1=153 mm 0,44 TVL_2 = 62 mm	3 mm lead and ≈ 210 mm concrete
60 patients	$\log_{10}$ (34,1 x 0,6) = 1,31	0,18 TVL_1 = 2 mm	0,82 TVL_1 = 172 mm 0,31 TVL_2 = 43 mm	2 mm lead and ≈ 210 mm concrete
40 patients	$\log_{10}$ (34,1 x 0,4) = 1,13	0,09 TVL_1 = 1 mm	0,91 TVL_1 = 191 mm 0,13 TVL_2 = 18 mm	1 mm lead and ≈ 210 mm concrete
20 patients	$\log_{10}$ (34,1 x 0,2) = 0,83	-	0,83 TVL_1 = 174 mm	175 mm concrete

TVL = tenth-value layer method

Remote access radiation monitor

- Patient continuous dose-rate monitoring
- Can be used to discharge the patient
- Decreases the radiation dose to the staff members
- Decreases the lenght of isolation periods



Sensire Dosimeter

Radiation isolation period, if 3,7 GBq is given and discharge limit is 400 MBq
→ Based on continuous measurements
1 – 2 days (typically 1 day)

Post-therapy radiation protection instruction for patient

- Previously, patients have received 3 to 4 weeks radiation protection instruction, which has limited their normal living
  - E.g. you are not allowed to spend time with children
- Measurements for the family members have shown, that their absorbed doses are negligible
- New recommendation: second radiation dose rate measurement during the after-therapy follow-up scan (typically 7 d from therapy)
- Based on the second measurement, new radiation protection instruction is given
  - For most of the patients (≈ 80%), radiation protection requirements can be discontinued completely because of the low external radiation dose rate
- Personalized radiation protection service
- In future no unnecessarily strict instructions are given, which may limit patients' living

Dosimetry and radiation protection survey for hyperthyroidism therapy

- 13 answers from Finnish clinicians treating hyperthyroidism
- What is your method to assess the given activity
- The sizes of given activities and indications
- Is there a demand for the personal dosimetry?
- Are the dosimetry models well known?
- Is there a need to nationally harmonize the radiation protection instructions?
- Do you need further information on dosimetry models and radiation protection?

Summary

- Clear need to nationally harmonize practices in the most common radionuclide treatment in Finland (and globally)
- New practices improve patient care, increase radiation protection, decrease false beliefs related to radiation risks and decrease the costs of treatment
- Nationally uniform practices decrease also the uncertainty among the patients and health-care professionals
- The novel techniques can increase staff safety and decrease treatment costs
- Currently these recommendations are implemented in practice

Thank you for your interest