RADIATION PROTECTION OPTIMIZATION IN NUCLEAR MEDICINE

Mario Medvedec, BSc(EE) MSc PhD
CED&HTAD/IFMBE Board
mario.medvedec@kbc-zagreb.hr

Division of Biophysics and Radiopharmacy
Department of Nuclear Medicine and Radiation Protection
University Hospital Centre Zagreb
University of Zagreb School of Medicine
Zagreb, Croatia

RADIATION PROTECTION AND SAFETY

Radiation protection and safety is the **protection** of people **from harmful effects of exposure to ionizing radiation** or due to radioactive material and the safety of sources, including the means for achieving this, and the means for preventing accidents, and for mitigating the consequences of accidents if they do occur.

OMPIMIZATION OF RADIATION PROTECTION AND SAFETY

Optimization of radiation protection and safety is the process of determining what level of radiation protection and safety would result in the **magnitude of individual radiation doses**, the **number of individuals** subject to public or occupational radiation exposure (members of the public, workers), and the **likelihood of radiation exposure** being **as low as reasonably achievable (ALARA)**, with physical, technical, economic, social, environmental and other factors being taken into account.

CLINICAL ENGINEERING AND CLINICAL DOSIMETRY IN PATIENTS WITH DIFFERENTIATED THYROID CANCER UNDERGOING THYROID REMNANT ABLATION WITH RADIOIODINE-131

INTRODUCTION

Differentiated thyroid cancer (DTC) is a malignant disease with increasing incidence worldwide.

Croatia is among the top European countries regarding the high incidence rate (10.2) of DTC, whereas DTC is among top fifteen primary cancer sites in Croatian population.

OBJECTIVE

Objective of this work is to present practical impact of clinical engineering in supporting and advancing care in patient with DTC by applying engineering and managerial skills to nuclear medicine technology.

Final goal of this work was to harmonize radioactive iodine-131 (I-131) ablation of thyroid remnant with desired clinical outcome, radiation protection and safety, quality of patient's life and costs of treatment.

MATERIALS AND METHODS

Study included 269 patients following total or near total thyroidectomy for DTC.

In 49 patients (group A) median 75 MBq and 1.9 GBq of I-131 were given for diagnostic and therapeutic purpose, respectively.

Serial measurements of I-131 activity in thyroid remnant and whole body were performed by conventional probe system (Figure 1), beta–gamma exposure rate meter (Figure 2) and whole-body counter (Figure 3) during first week after I-131 had been given for diagnostic and therapeutic purpose, 4 and 5 weeks postthyroidectomy, respectively.

MATERIALS AND METHODS

Figure 1. Measurement of radioactive iodine-131 activity in the neck and thigh (for background correction) by using conventional probe system.

Figure 2. Measurement of whole-body and neck activity of radioactive iodine I-131 by using scanning-bed whole-body counter equipped with especially designed slit-collimator.

Figure 3. Measurement of neck surface dose rate and one-meter distance whole-body dose rate of radioactive iodine-131 by using beta–gamma exposure rate meter.

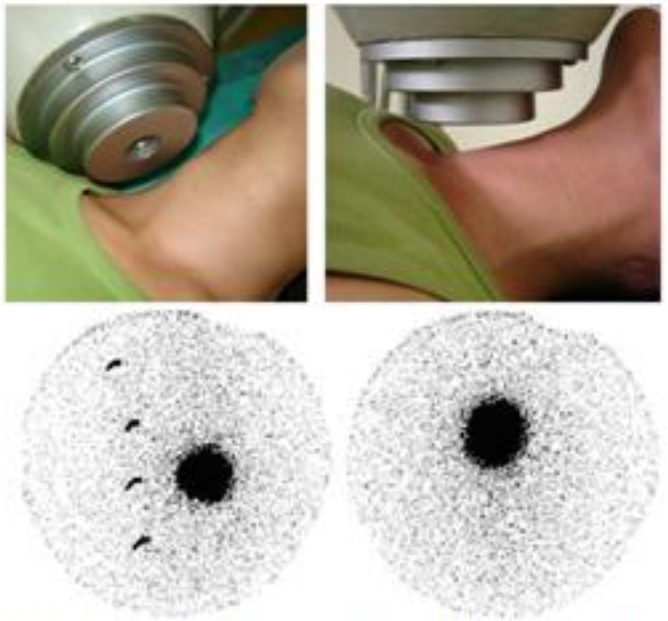

Figure 4. Lateral (left; marked neck surface) and anterior (right) scintigraphic imaging of radioactive iodine-131 concentrating tissue in the neck by using gamma camera equipped with pinhole collimator.

MATERIALS AND METHODS

Mass of residual thyroid tissue was determined from two orthogonal images obtained by gamma camera equipped with pinhole collimator and assuming ellipsoidal shape (Figure 4).

Internal radiation absorbed doses were calculated by applying Medical Internal Radiation Dose (MIRD) formalism.

The study also included 220 low risk DTC patients (group B) who had been treated for thyroid remnant with only 0.9 GBq of I-131 and were followed up for five years.

RESULTS

The biokinetics of diagnostic and therapeutic I-131 were found far from being approximately equal, but were still correlated.

Cumulative activity per unit administered activity of therapeutic I-131 was about twice lower then diagnostically expected value, i.e. „thyroid stunning“ was found to be a real phenomenon.

Absorbed dose of diagnostic I-131 in thyroid remnant was main cause of thyroid stunning, already at low diagnostic absorbed doses of I-131 of only few Gy.

RESULTS

Therapeutic absorbed dose and dose rate of I-131 sufficient for complete thyroid remnant ablation were found to be, at least, one third lower than currently recommended values (300 Gy and 3 Gy/h, respectively).

Thyroid stimulating hormone (TSH) concentration following total or near total thyroidectomy reaches recommended value of 30 mU/L usually within 3 weeks, but neither the absorbed dose nor the absorbed dose rate of I-131 in thyroid remnant was found to be significantly dependant on TSH concentration.

High success rate but prolonged complete ablation was achieved in 80% of patients and 85% of lesions in group B.

RESULTS

Table 1. Names, average quantities and costs of most important items routinely applied to post-thyroidectomy thyroid remnant ablation with radioactive iodine-131 (I-131) in patients with differentiated thyroid cancer treated in our nuclear medicine department during different time periods.

Item	Quantity × Cost [€]		
time period	≤1994	1995-1999	≥2000
1st hospital day	1×41	1×41	1×41
≥2nd hospital day	9×37	6×37	2×37
bone scintigraphy	1×135	0×135	0×135
TSH measurement	1×8	1×8	2×8
Tg measurement	1×16	1×16	2×16
TgAt measurement	1×18	1×18	2×18
pre-ablation I-131 scintigraphy (185 / 74 MBq)	1×65	1×57	0×57
thyroid ablation (4.44 / 1.85 / 0.9 GBq)	1×313	1×111	1×70
post-ablation I-131 scintigraphy	1×52	1×52	1×52
sick leave/off work days	40×42	30×42	20×42
total [€]	2661	1785	1161

CONCLUSIONS

Clinical engineering efforts integrated into novel dosimetry-based approach applied to low risk patients with differentiated thyroid cancer undergoing thyroid remnant ablation with radioactive iodine-131 in clinical setting of our institution:

- decreased overall patient's procedure time and costs more than two-folds

- dereased amount of applied radioactivity more than five-folds

- preserved high success rate of thyroid remnant ablation

- improved quality of patient's life and radiation protection and safety