MEASUREMENTS OF IODINE UPTAKE IN THYROID AFTER DIAGNOSTIC ADMINISTRATION OF ^{131}I

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Introduction

The administration of therapeutic activity of ^{131}I radioiodine is usually preceded by a diagnostic administration, done for examination of thyroid function. The quantity of interest is the iodine uptake determined from total activity of iodine in thyroid gland, measured in some time after the ingestion of known activity of ^{131}I. In some cases, the therapeutic activity, calculated from such data appears to be non-effective, and the patient receives an additional portion of radioiodine. Usually there is no possibility to measure so high activity using the standard clinical equipment and the second dose is given without any measurement of the real content of ^{131}I in thyroid. It is clear that the increase of the administered activity will cause a great increase of the radiation dose for the patient and also the increasing release of radioiodine from the patient's body. Moreover, the procedure should be considered as unjustified, if the content of the iodine in thyroid already reached its maximum.

The second administration of ^{131}I is based on an assumption that the real radioiodine uptake was lower than expected because of one of two possible reasons – either the uptake in the thyroid is lower at high therapeutic doses than at the diagnostic ones, or the value of the uptake was incorrectly determined during the diagnostic procedure.

Sometimes, such incorrect results may appear because the thyroids of the patients are generally far from standard ones, concerning their weight and depth in the neck tissue. The last problem can be at least partly override if the energy spectrum of the radiation emitted from the thyroid is measured. This paper presents the results of calibration of a NaI scintillation counter, with regard to the thyroid depth [1] and the results of measurements performed for a group of patients who received a diagnostic dose of ^{131}I in Nuclear Medicine Department in Brodno Regional Hospital in Warsaw [2].

Method

Energy spectrum, of the radiation emitted from the thyroid, includes all the peaks of the ^{131}I emission spectra, attenuated by the tissue layer between the emission point and the scintillation counter, as well as a broad energy band of Compton scattered radiation. It was expected, that the shape of the spectrum will depend on the effective depth of the thyroid gland, because both attenuation and Compton scattering depend on this depth but in different way.

In order to select the proper parameter of the spectrum, the counting rate was determined for three common peaks of 30, 80 and 364 keV and additionally for the whole spectrum and for the energy band between 100 and 150 keV. Analysis of the results showed that the most accurate way to determine the thyroid depth is to use the value of the ratio of the counting rate for 364 keV peak to the counting rate for the energy band from 100 to 150 keV (see Fig. 1). The plot of this ratio in dependence of the thyroid depth (Fig. 3) has the highest slope, comparing with the other investigated parameters, therefore the value of this ratio is the most sensitive to the change of the thyroid depth. The detector efficiency, ε, for the 364 keV peak, was determined in dependence on thyroid depth, so the appropriate value can be used for each individual person.

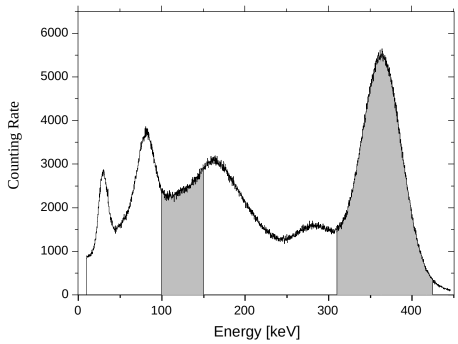


Fig. 1. Energy spectrum of ^{131}I gamma radiation, measured with scintillation detector (NaI). Marked areas under the curve were used for determination of the effective depth of the thyroid gland.

Calibration of the counter

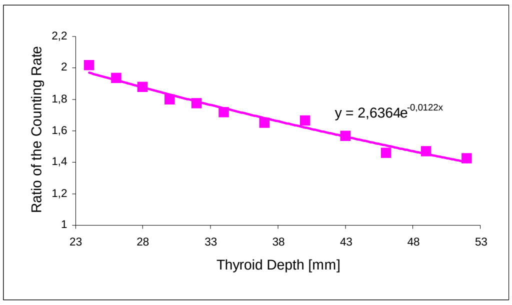
The thyroid counter from the Institute of Atomic Energy, used for this work, has a NaI(Tl) scintillation detector (Tesla) with beryllium window, mounted in the SS-33W52 counter (manufactured by POLON, Bydgoszcz, Poland).

A special phantom of human neck and thyroid was designed. This is cylinder shaped vessel (128 mm diameter, 165 mm high), with a cover and two small PMMA (13 cm^3)

cylinder vessels inside the big one (Fig. 2). During the measurements, the big vessel is filled up with distilled water and small ones with solution of iodine ^{131}I of known activity.

Fig. 2. Water phantom of human neck used in this work.

The energy spectra of the radiation emitted from the phantom, were recorded for 10 simulated depths from 24 to 52 mm, while the distance between detector and the neck phantom surface was always equal to 12 cm. Radiation energy spectrum was measured in the range from 15 keV to 450 keV.



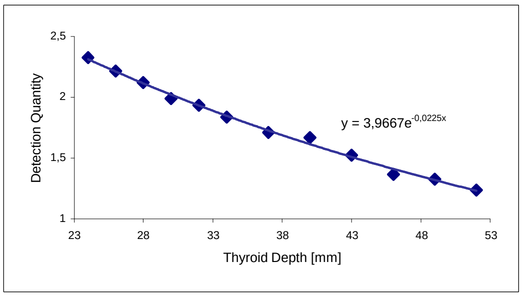


Fig. 3. Left - ratio of the counting rate in 364 keV peak to the counting rate in the Compton scattering band (100– 150 keV), in dependence on the depth of the calibration source in the phantom. Right - ratio of the detection efficiency in dependence on the depth of the calibration source in the phantom.

The resulting dependence of the ratio of the counting rate in 364 keV peak to the counting rate in the Compton scattering band (100– 150 keV), S, on the thyroid center depth, d, can be estimated as:

$$S = 2.64\,e^{-0.012d} \tag{1}$$

and the efficiency for the 364 keV peak can be expressed as:

$$\varepsilon = 3.97\,e^{-0.0225\,d} \tag{2}$$

Measurements

During the tests in hospital, the activity of iodine ^{131}I in thyroid gland was measured about 24 hours after swallowing the pills with isotope. A considerably large number of 98 patients were subjected to the measurements. In all the cases, the routine measurements were performed by the hospital staff and then repeated by the IAE researches using their specially calibrated counter. Time of each IAE measurement was equal to 10 minutes. The counting rate was determined for three common peaks 30, 80 and 364 keV and for some energy bands between them. The ratio of the counting rate in 364 keV to the counting range in energy band from 100 to 150 keV was then used for determination of effective depth of the thyroid gland.

The effective depth was determined using the results of earlier calibration. The ratio S, of the counting rate in 364 keV peak to the counting rate in the energy band from 100 to 150 keV was related to the effective depth using the equation (1) and the activity of ^{131}I in thyroid at the time of measurements was calculated from the equation (2).

The iodine activity in thyroid, determined from the spectrometric measurement was always higher than those measured by standard method. In most cases the difference was below 30%, so of no practical importance. However, there was a group of patients (about 20% of the investigated group) who needed more careful consideration. In these cases, the shape of the measured spectra indicated large depth of thyroid, even over 50 mm. In these cases the error of standard measurements of the iodine uptake can exceed 100%.

Conclusions

The measurements performed up to now, showed that the spectrometric measurements can be useful in selection of the patients who need special consideration during the ^{131}I diagnostics and treatment. The next step of the work will include the measurements of the real activity of ^{131}I in thyroid gland, after the therapeutic administration of radioiodine. A special collimator was designed for this purpose and the thyroid counter was calibrated using a phantom with inserts simulating different shapes of pathologically changed thyroid glands. It can be expected that the improvement of accuracy of the diagnostic measurements and better control of real activity of ^{131}I in thyroid gland after the therapeutic administration will contribute to the process of optimisation of radiation doses to the patients and medical personnel.

References

1. J. Osko, T. Pliszczynski “A method for calibration of thyroid counter with regard to depth of thyroid gland” IAE Annual Report 2001, Otwock – Swierk, Poland
2. J. Osko, T. Pliszczynski “Measurements of iodine uptake in thyroid after diagnostic administration of ^{131}I” IAE Annual Report 2001, Otwock – Swierk, Poland