Rapid Measurement of $^{131}$I in the Thyroid Gland
Using a Portable Ge System

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Rapid yet accurate measurement of the $^{131}$I activity in the thyroid gland as well as in the air, water and
vegetation may have an important role in obtaining quantitative information on internal doses for the people
living in the vicinity of nuclear facilities shortly after an accidental release of radionuclides (1-2). Whole body
counting technique is still the standard method for measuring radionuclides (3) in the body while necessity for in
situ measurement techniques (4) has considerably increased especially after the Three Mile Island and Chernobyl
accidents. For measurement of $^{131}$I in the thyroid gland in emergency situations, NaI (Tl) detectors, as in a
scintillation survey meter as in the simplest case, are most often used (5) while measurement of urinary
excretions for members of the public may also effective (6). The scintillation survey meter method, being easily
implemented, may not have enough selectivity for radioiodine and even be liable to an elevated background
radiation spectrum. This would possibly lead to higher detection limits and lower accuracy. A use of a laboratory
Ge (Li) detector system in the thyroidal radioiodine measurement was suggested to overcome the problem (7). A
real measurement with a similar instrument was reported for the residents in U. K. after the Chernobyl accident
(8). A use of a scintillation spectro-survey meter with a NaI (Tl) probe with lead collimation to thyroidal
radioiodine measurement was also reported to give satisfactorily accurate evaluation of the thyroidal $^{131}$I burden
(9).

In this paper, a movable Ge system was developed for the above purpose and preliminarily evaluated
particularly for counting efficiency. It is consisted of a portable high-purity Ge detector and a battery-operated
MCA. It employs a laboratory made thin Pb shield with a collimation window and an elevator for the detector
platform. The elevator was designed to adjust the height of the thyroid radioiodine probe in relation to the height
and position of the neck of a subject sitting in a chair. Gamma spectra were analyzed and stored by the portable
MCA. The acquired spectral information, sent to a notebook computer on line, was processed for determination
of the $^{131}$I activity. In the preliminary measurement, the system was checked for its counting efficiency for $^{131}$I
radioactivity by using neck-thyroid phantoms for the adult and some different ages that were previously prepared
(5). The absolute counting efficiency was observed to be satisfactory, i.e. 0.20 to 0.28 %. However, it was
suggested that certain modification in the shield part of the probe might improve counting efficiency.

MATERIALS AND METHODS

A 5-cm dia. HP Ge coaxial detector, detachable and portable (EG & G Ortec Model GEM- 20180P)
with a 1.2 l liquid nitrogen cryostat was used together with a laboratory made 1 cm-thick Pb shield, consisting
the thyroidal $^{131}$I detection probe. The cross section of the probe wall was consisted of 5 mm plastic, 5 mm Cu,
10 mm Pb and 10 mm Fe as the outer shell. A collimator part had the same structure with a window of 50 mm I.
D. The probe, 140 mm in O. D. and 255 mm in length, was fixed on a platform, the height of which was adjusted
by a hand driven elevator close to the position of the neck of a subject who may sit on an office chair, which
having also a height adjustment lever. The platform-elevator was on a movable stand.

The system was checked for $^{131}$I radioactivity using three of the five old neck-thyroid phantoms to
compare the result with the previous one (7). These were laboratory made to simulate the thyroid gland of the
adult (20-50 years), 14-16 and 1-2 years of normal Japanese as previously described (5). The standard $^{131}$I
solutions, approximately 50 g in weight and having a calibrated radioactivity of 0.944 and 1.05 kBq g$^{-1}$ with a
total uncertainty 2.8 and 3.0 %, respectively at 95.5 % confidence level (Code No. IO-050, Japan Radioisotope
Association, Tokyo), were used. They were diluted with a specified medium and transferred to a pair of plastic
vials simulating human thyroid gland (5).

Counting time was chosen as 200 s for quick measurements (7). The energy calibration was set at 2.0
keV per channel so that the $^{131}$I 364 keV peak was observed at 728 ch. The signal was analyzed and stored by the
portable MCA operated by rechargeable batteries (EG & G Ortec Model DART). The obtained gamma spectrum
was transported to a notebook computer (IBM Model ThinkPad 380Z) installed with gamma analysis software
(Seiko EG & G Gamma Studio) for further determination of radioiodine and printing out the results.
RESULTS AND DISCUSSION

The results of measurements to obtain preliminary estimates of counting efficiency of the present movable Ge thyroid radiiodine detector system by using three sizes of the neck-thyroid phantom are shown in Fig. 1-3.

Variation of efficiency along the probe height against the “thyroid” ¹³¹I source in the adult phantom is shown in Fig. 1. The counting efficiency was observed to be almost at a plateau when the center of the probe is positioned at 0 to 15 mm lower with respect to the height of the “thyroid”. The distance between the probe head and the frontal surface of the neck-thyroid phantom at its sagittal plane does influence counting efficiency and this was examined for a distance between 20 to 50 mm by a 10 mm increment. As shown in Fig. 2, the efficiency steadily decreased as the distance increased to 40 mm from the neck, and then appeared almost constant between 40 and 50 mm as shown. This was also checked with the 14-16 and 1-2 years phantoms, and, in the latter, a plateau was seen between 30 and 40 mm from the front surface of the phantom and then the curve considerably dropped toward 50 mm as can be seen in Fig 3.

In the previous work, the phantom was set to the face of the shield (7) but this seemed almost impossible due to geometric hindrance of the probe against the chin when using a probe having a larger diameter than that of conventional survey meters with 1-in. Na crystal. A practicable distance between the probe head and the front surface of the neck under the conditions appeared to be 30 mm or larger.

From the above data, the probe head should be set at 30 mm as the minimum or 40 mm as a compromise from the front surface of the neck at the height of the thyroid ¹³¹I source under the instrumental conditions. In this study, 30 mm was chosen not to lose efficiency in the adult phantom.

Fig. 1. Effect of relative height of detector probe to “thyroid source” on counting efficiency at a probe head- to-neck surface distance 30 mm in the adult phantom.

Fig. 2. Effect of probe head-to-neck surface distance on efficiency at the optimum height 0 in the adult phantom.
A summary of the obtained data is presented in Table 1. The absolute efficiency for $^{131}$I in the phantoms simulating the Japanese adult, 14-16 and 1-2 years was approximately 0.20, 0.23 and 0.28 %, respectively with a distance of 30 mm between the probe head and the front surface of the phantoms at their sagittal plane. From the Table, the efficiency for each phantom obtained in the present work was calculated to be about 34, 50 and 63 % for the 1-2, 14-16 and 20-50 years, respectively of that previously reported (7). In the previous study, a horizontally positioned coaxial open-end Ge (Li) detector with an active volume of 40 cm$^3$ was used with a box-shaped lead shield. The system was primarily used for measurement in nuclear activation analysis (7). In that experiment, the front surface of the phantom was held 12 mm apart from the detector head, which was the distance between the detector head and the outer surface of the lead shield, to which the front end of the phantom was contacted.

Detection limits should be studied. There would be a possibility for improving efficiency by partly modifying the shield.

<table>
<thead>
<tr>
<th>Phantom size</th>
<th>1-2 years</th>
<th>14-16 years</th>
<th>20-50 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counting efficiency (%)</td>
<td>Present result</td>
<td>0.28±0.051</td>
<td>0.23±0.02</td>
</tr>
<tr>
<td></td>
<td>Previous work (7)</td>
<td>0.83</td>
<td>0.46</td>
</tr>
</tbody>
</table>

CONCLUSION

A movable Ge detector system intended for use in the rapid and accurate measurement of $^{131}$I in the thyroid gland in an emergency situation was briefly described and preliminarily evaluated for counting efficiency. The probe head-to-neck distance 30 mm was employed because of the geometric hindrance caused by the large diameter of the probe. The counting efficiency was found to be between 0.28 to 0.20 % for three sizes of the neck-thyroid phantom for 1-2, 14-16 and 20-50 years (adult) of normal Japanese. Further study on detection limits and improvement of the shield unit was suggested.

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