Effects of Potassium Iodide and Methylthiouracil on Thyroid Uptake and Whole-Body Burden of Radioiodine

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The effects of stable iodine and antithyroid drug were studied, in respect to a first aid at internal contamination accidents of radioiodine. Rats were given various doses of KI or methylthiouracil, changing intervals between the administration of \(^{131}\)I and these drugs, and the thyroid uptake of \(^{131}\)I was measured with a stand-type scintillation counter and the whole-body burden with an animal counter.

By administrating 1.0 mg/kg of KI or 10.0 mg/kg of methylthiouracil, the thyroid uptake and the whole-body burden were decreased to about 10 and 30 per cent of the non-administered group, respectively. And in the case when longer interval had elapsed after the intake of \(^{131}\)I, methylthiouracil was found to be more effective than KI.

Introduction

The development of nuclear reactors and the rapid growth of the utilization of radioactive materials have brought serious problems of internal contamination accidents.

Radioactive iodine is one of the most important elements, because of the two points:

1. Its fractional abundance is great among the fission products released out of the reactor at accidents.
2. It is selectively absorbed and concentrated in the thyroid gland, and is retained for relatively long period.

In case of the reactor accidents, it is necessary to prevent the thyroid uptake and to enhance the bodily elimination of radioiodine as soon as possible.

In this study, animal experiments were carried out to investigate the effects of stable iodine and antithyroid drug, which are applied to block the uptake of radioiodine into the thyroid gland and to enhance the elimination of it from the body.

Method

Wistar strain rats (female, 2 month old, 150-200 g) were used in groups of from five to ten.

Amounts of 0.3–1 \( \mu \) Ci/0.1-0.5 ml of carrier free \(^{131}\)I were administered orally with a stomach tube.

An animal counter was used to measure the...
whole-body radioactivity. The counter consists of a 3 in. $\phi \times 2$ in. NaI(Tl) scintillation detector, an iron shield of 12 cm thick, a 2 channel pulse height analyzer and a scaler, and is able to measure intermittently or continuously the whole-body activity of an individual small animal in vivo (Fig. 1). The rat anesthetized by Nembutal, was put into a plastic container and was set just under the NaI detector (Fig. 2). The calibration uncertainty due to the internal distribution of $^{131}$I and the difference of positions of the rats was estimated at less than 5 per cent.

For the purpose of measuring the thyroid uptake, the thyroid gland removed from the rat was measured with a 1 in. $\phi \times 1$ in. NaI(Tl) scintillation counter.

The whole-body burden and the thyroid uptake were expressed as a ratio to the administered dose.

The rats were given various amounts of stable iodine (KI) and methylthiouracil via intraperitoneal injection, changing intervals between the administration of $^{131}$I and these drugs.

**Results**

1. **Retentions of $^{131}$I in the whole-body and in the thyroid gland**

   In order to investigate the retentions of $^{131}$I in the whole-body and in the thyroid gland after the single oral administration, measurement was carried out during 21 days. From these results, biological retention values were deduced.

   As is shown in Fig. 3, the whole-body retention curve can be expressed in exponential function of two components which have biological half lives of 3.3 days and 7.9 days. The thyroid uptake at 24 hours after the administration of $^{131}$I is 11.4 per cent of the administered dose, and it corresponds to 54 per cent of the whole-body retention. After that, $^{131}$I in the thyroid gland reduces with half life of 7.7 days, which agrees with the second component of the whole-body retention curve.

2. **Effects of the administered doses of KI and methylthiouracil**

   Various amounts of KI and methylthiouracil were administered at the same time with $^{131}$I and the effects on the thyroid uptake were observed at 24 hours. The results were compared with that of the non-administered group.
(this is referred to as the "control group" in the remainder of this paper).

The relations between the amounts of KI or methylthiouracil and the thyroid uptake are shown in Fig. 4. It is recognized that the administration of 1.0 mg/kg of KI or 10.0 mg/kg of methylthiouracil is able to reduce the thyroid uptake of $^{131}$I to less than 10 per cent of the control group.

3. $^{131}$I retentions in the whole-body and in the thyroid gland under the administration of KI or methylthiouracil

In Fig. 5, 6 are shown the retention curves for 6 days after the rats are administered 1.0 mg/kg of KI or 10.0 mg/kg of methylthiouracil at the same time with $^{131}$I.

The comparisons among three groups, namely the KI, the methylthiouracil and the control group are shown in Fig. 7, 8 and Table 1, 2.

Fig. 7 Comparisons of the whole-body retentions of $^{131}$I among control, KI and methylthiouracil group.

Fig. 8 Comparisons of the thyroid retentions of $^{131}$I among control, KI and methylthiouracil group.

Table 1 Comparisons of biological retention values of $^{131}$I in the whole-body and in the thyroid gland

<table>
<thead>
<tr>
<th>Days</th>
<th>Whole-body</th>
<th>Thyroid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KI Control</td>
<td>Methyl. Control</td>
</tr>
<tr>
<td>1</td>
<td>0.66</td>
<td>0.44</td>
</tr>
<tr>
<td>2</td>
<td>0.32</td>
<td>0.28</td>
</tr>
<tr>
<td>3</td>
<td>0.28</td>
<td>0.31</td>
</tr>
<tr>
<td>4</td>
<td>0.30</td>
<td>0.32</td>
</tr>
<tr>
<td>5</td>
<td>0.32</td>
<td>0.33</td>
</tr>
<tr>
<td>6</td>
<td>0.32</td>
<td>0.33</td>
</tr>
</tbody>
</table>
From these results, it is recognized that the thyroid uptake and the whole-body burden of \(^{131}\text{I}\) can be reduced to about 10 per cent and 30 per cent of the control group, respectively, by using KI or methylthiouracil.

The integrated amounts of the effective retention curve of \(^{131}\text{I}\) during first 7 days are listed in Table 3. With KI or methylthiouracil, the amounts in the thyroid gland and in the whole-body are decreased to about 10 and 50 per cent, respectively.

Table 2 Ratio of \(^{131}\text{I}\) in the thyroid gland to the whole-body

<table>
<thead>
<tr>
<th>Days</th>
<th>Control</th>
<th>KI</th>
<th>Methyl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.53</td>
<td>0.06</td>
<td>0.12</td>
</tr>
<tr>
<td>2</td>
<td>0.75</td>
<td>0.16</td>
<td>0.27</td>
</tr>
<tr>
<td>3</td>
<td>0.74</td>
<td>0.18</td>
<td>0.24</td>
</tr>
<tr>
<td>4</td>
<td>0.78</td>
<td>0.17</td>
<td>0.23</td>
</tr>
<tr>
<td>5</td>
<td>0.82</td>
<td>0.16</td>
<td>0.25</td>
</tr>
<tr>
<td>6</td>
<td>0.77</td>
<td>0.17</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Table 3 Integrated amounts of effective retentions of \(^{131}\text{I}\) of the whole-body and the thyroid gland during first 7 days

<table>
<thead>
<tr>
<th></th>
<th>Whole-body*</th>
<th>Thyroid**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.037</td>
<td>0.469</td>
</tr>
<tr>
<td>KI</td>
<td>0.595</td>
<td>0.031</td>
</tr>
<tr>
<td>Methyl.</td>
<td>0.517</td>
<td>0.049</td>
</tr>
</tbody>
</table>

\[
R(T)=\int_0^TA_0e^{-0.693/T_{1/2}T}dT + \int_0^7A_0e^{-0.693/T_{1/2}T}dT
\]

** Thyroid:

\[
R(T)=\int_0^1A_1(1-e^{-0.693/T_{1/2}T})dT + \int_1^7A_1e^{-0.693/T_{1/2}T}dT
\]

amounts in the thyroid gland and in the whole-body are decreased to about 10 and 50 per cent, respectively.

4. The effect of the interval between the administration of \(^{131}\text{I}\) and KI or methylthiouracil

It is understood that methylthiouracil is more effective than KI, in case if longer interval is elapsed between the administration of \(^{131}\text{I}\) and these drugs (Fig. 9).

Discussion

It is known that stable iodine and antithyroid drug have blocking effects to the thyroid uptake of radioiodine.\(^{13-15}\) In this experiment, the effects of KI and methylthiouracil were ex-
amined. And it was recognized that these drugs are useful for the blocking of the thyroid uptake but are not so effective in the discharge of radiiodine from the body. According to the report of ICRP II, 1958,6) the values of the Maximum Permissible Body Burden of $^{131}$I in reference to the thyroid gland and the whole-body are 0.7 $\mu$Ci and 50 $\mu$Ci, respectively. Therefore, the authors consider that it is unnecessary to take any more action which enhances the bodily elimination, if the thyroid uptake has been suppressed to the safety level by administrating stable iodine or antithyroid drug.

In case of applying these drugs to the human body, it must be taken account of the following points;

(1) reasonable administrating doses of stable iodine and antithyroid drug
(2) time lapses between the intake of radiiodine and the administration of these drugs.

For the first point, it was recognized in this experiment that 1.0 mg/kg KI or 10.0 mg/kg of methylthiouracil were effective to reduce the thyroid uptake to less than 10 per cent of the control group. A few papers are reported concerning to therapeutic and toxic doses of stable iodine, and 100 mg of KI is recommended as one blocking dose at the acute exposure of radiiodine.2) On the other hand, further investigations are necessary for the application of antithyroid drug.

As regard to the second point, stable iodine or antithyroid drug should be given as soon as possible after the intake of radiiodine. But when longer interval had elapsed, methylthiouracil was found to be more effective than KI. Namely, KI should be given within 30 minutes after the intake to decrease the thyroid uptake to less than 10 per cent of the control group, while methylthiouracil within two hours.

**Conclusion**

Effects of KI and methylthiouracil on the thyroid uptake and the whole-body burden of $^{131}$I were examined in the animal experiment. The following points can be remarked.

(1) By the administration of 1.0 mg/kg of KI or 10.0 mg/kg of methylthiouracil, the thyroid uptake of radiiodine was decreased to about 10 per cent of the control group and the whole-body burden to about 30 per cent.

(2) KI and methylthiouracil were less effective in the discharge of radiiodine from the body. But it seems unnecessary to take any action which enhances the bodily elimination.

(3) In case when longer interval had elapsed after the intake of radiiodine, methylthiouracil was more effective than KI.

**Acknowledgement**

The authors are indebted to Dr. H. Katsu numa for valuable advice and encouragement.

**References**

3) Pochin, E.E. and Barnaly, C.F.: Health Physics, 7, 125 (1962)
6) Report of Committee II of Permissible Dose for Internal Radiation, 1958 Revision (ICRP Publication 2)
要旨

ヨウ化カリおよびメチルサイオウラシルの甲状腺摂取と放射性ヨウ素の全身負荷

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放射性ヨウ素の体内汚染事故時の救急処置法として，KIおよびメチルサイオウラシルの131I甲状腺摂取阻止効果，体外排泄効果につき検討した。ラットに2種薬剤を投与量，投与時間を変化させて与え，甲状腺および全身中の131Iをスタンド型シンチレーションカウンターおよびアニマルカウンターを用いて測定した。その結果，(1) 1.0 mg/kgのKIあるいは10.0 mg/kgのメチルサイオウラシルを131Iと同時投与することにより，24時間後の甲状腺，全身中の131Iを非投与群のそれぞれ約10％，30％に減少させること，(2) 131I摂取後1か週の時間が経過した場合には，KIよりもメチルサイオウラシルのほうが有効であること，が認められた。