

1954 to 1958, representative ovine thyroids in Europe and North America contained a maximum of 10,000 pCi ^{131}I /g (370 Bq/g) and had received 30 rad (0.30 Gy) from ^{131}I ; even a major accidental addition of 20,000 Ci from Windscale was relatively small compared to the contamination from weapons tests.

After international agreements to ban atmospheric nuclear tests, the ^{131}I was reduced temporarily; however, after one and two years, periods of major contaminations were recorded. They were relatively uniform in the northern hemisphere, averaging peaks of 1,000 pCi/g (37 Bq/g) for less than one month each year.

After 1961, underground testing was used more often; and by 1963, there was a clear reduction of prolonged periods of sustained ^{131}I in animal thyroids. However, in almost every year from 1963 to 1986, there were short bursts of ^{131}I contamination in both hemispheres lasting

one to two months and reaching 100 to 1,000 pCi ^{131}I /g (3.7–37 Bq/g).

After April 26, 1986, there was a relatively heavy contamination by ^{131}I in animal thyroids; but it was nonuniform, and the average intensity increased rapidly toward central Europe. The ^{131}I was associated with ^{134}Cs and ^{137}Cs , but the ^{131}I concentration was more than 10,000 times greater than that of the cesium isotopes. The pattern of maximum concentrations of ^{131}I in cattle thyroids in the northern hemisphere fit a straight line regression as the inverse square of the distance from Chernobyl, U.S.S.R.

These data may be the only source of a continuous record of thyroid environmental ^{131}I exposure experienced by the animal population of the earth during the past 33 years.

Key words: Thyroid, ^{131}I , Radioactive fission products, Nuclear accidents, Nuclear weapons tests.

6. MEDICAL RADIATION: Comparison of ^{131}I and Alternative treatments of Hyperthyroidism

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Medical radiation makes up almost one-half of the total annual whole body radiation dose equivalent and nuclear medicine procedures constitute about one-fifth of such medical radiation. Of the latter, only ^{131}I therapy delivers large absorbed doses, including whole-body (marrow) dose equivalents of greater than 3 to 5 rem. In evaluating the usefulness and safety of radiation therapy, particularly of a benign disease, one must be confident that the potential risks are less than those from other available effective therapies. Selection of a particular treatment of Graves' disease, for example, requires careful evaluation of the safety and effectiveness of alternatives. Antithyroid drugs have a low remission rate (10 to 30%) and moderate toxicity and thus have limited applicability. Subtotal thyroidectomy is effective and rapid but has a significant morbidity and a small but definite mortality. As patients increasingly elect radioiodine therapy, surgical experience with this disorder has decreased with a consequent increase in complications.

In the 35 years since ^{131}I has been introduced, it has been effectively used to treat more than one million hyperthyroid patients with safety and convenience.

Evidence that radiation caused cancer, leukemia and genetic effects in some situations raised initial concerns. External x-ray to the neck of children and the atomic bomb and Marshall Island experiences with mixed radioiodine isotopes has shown the potential of these agents to cause thyroid nodules and thyroid cancer. However, a number of careful follow-up studies of patients treated with both diagnostic and therapeutic ^{131}I has not demonstrated an increased incidence of thyroid nodules or cancer in these patients. The absence of such findings has been attributed to the effects of ^{131}I in decreasing the thyroid follicular cell population at risk as well as its ability to respond to thyroid stimulating hormone. Other studies have shown no difference in the incidence of leukemia in radioiodine treated patients as compared to hyperthyroid patients treated with other methods of therapy. Genetic consequences of radiation are difficult to detect but measurements and calculations of gonadal dose from ^{131}I therapy are within the range of that from commonly used diagnostic x-ray procedures. If there is an increased risk of genetic effects from therapeutic ^{131}I , it is very low.

Comparison of the risks of ^{131}I treatment of Graves' hyperthyroidism with those for antithyroid drugs and surgery suggest that although antithyroid drugs may be acceptable initial therapy for selected younger patients

with small glands and mild disease, ^{131}I appears to be the preferred treatment for the majority of adults with Graves' hyperthyroidism.

7. 放射線治療——日本の場合——

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甲状腺疾患の放射線治療としてはバセドウ病および甲状腺癌に対する ^{131}I 療法と、未分化癌や悪性リンパ腫に対する外部照射療法が行われている。これらのうちバセドウ病の ^{131}I 療法は日本においてもその歴史がすでに30年を越え、抗甲状腺剤療法や手術と並ぶ代表的な治療法となっている。この治療法は良性疾患に対する放射線療法という点でも特異な存在であり、その治療効果、副作用についてはこれまで注意深い経過観察がなされている。ここでは演者らの施設において ^{131}I 治療を行ったバセドウ病患者の治療後長期にわたる調査成績について述べ、その評価を行いたい。

対象は昭和31年より60年までに ^{131}I 治療を受けた762例であり、治療後3～5年ごとに調査を行ってきた。 ^{131}I の総投与量は2～61 mCi に分布し、平均値は7.1 mCi であった。初回投与量の平均値は昭和45年までは5.3 mCi、46～48年は4.1 mCi に減量、その後は6 mCi と再び増加している。平均投与回数は昭和45年までが1.6回、46～48年は1.1回（原則として再投与せず）、その後は1.3回であった。 ^{131}I 投与後の経過年数別にみた治療成績では1年後に52%が機能正常化しており、亢進例は35%、潜在性低下2%、低下例が11%であった。5年後には亢進が13%、正常56%、潜在性低下7%で、低下例が24%であった。これに対し、15年後には亢進4%、正常32%、潜在性低下11%で、低下は53%に上り、この間、年平均3%の割合でほぼ直線的に機能低下症の増加が認められた。

総投与量が11 mCi 以上の症例は難治例が多いため、初期には機能低下の頻度が低かったが、15年後には他群と同程度に低下症の発生がみられた。一方、推定甲状腺重量1 g 当たりの摂取 ^{131}I 量別に機能低下症の頻度を

みると75 $\mu\text{Ci/g}$ 以上の群では5年後に25%、50 $\mu\text{Ci/g}$ 未満群では14%であり、摂取量の少ないもので低下症の発生が遅延する傾向がみられた。

昭和46～48年の間、上記のように減量療法を試み、機能低下症の発生をそれ以前の治療例のうちの1回投与群（平均5.2 mCi 投与）を対照として比較検討した。その結果、減量群での機能低下率は当初低率であったが、7年目以後は対照群とほぼ同じであった。したがって投与量を4 mCi 程度に減量することにより機能低下症の発生を遅らせることはできるものの根本的に防止することはできないと考えられた。

副作用としては一過性機能低下症7例のほか、昭和61年度に診察した患者146例中4例に甲状腺結節を認めた。治療後14～28年を経過した女性で、投与量は3～9 mCi、全例機能は正常であった。多発性、単発性各2例で、いずれも嚢胞状変性を伴う良性結節であり、甲状腺癌はみられなかった。一方、白血病が2例、その他の悪性腫瘍として、胃癌3例、悪性リンパ腫2例、肝癌1例、子宮癌1例がみられた。

以上のように、 ^{131}I 療法はバセドウ病に対して確実な効果が期待できる有効な治療法であり、早期あるいは晩発性の副作用としてもこれまで統計的に問題となる異常はみられていない。しかし、長期経過後には高率に機能低下症が発生することが避けられないことが判明してきた。したがって、今日 ^{131}I 療法の適応となる症例、特に合併症のある症例や、副作用のために抗甲状腺剤の使用できない症例などでは確実な治療効果を得るため、晩発性機能低下症を覚悟の上で、十分量の ^{131}I で治療するのがよいと考えられる。これらの点について、これまでの日本における諸家の集計成績ともあわせ考察を加えてみたい。