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**Iodine Instruction Sheets –
Use of iodine tablets for thyroid saturation
following a nuclear accident**

Iodine Instruction Sheet 1: Instruction sheet for the population
Iodine Instruction Sheet 2: Instruction sheet for doctors

Recommendation by the German Commission on Radiological Protection

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11/12 December, 1997

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**Iodmerkblätter –
Verwendung von Iodtabletten zur Iodblockade der Schilddrüse bei einem
kerntechnischen Unfall**

Iodmerkblatt 1: Merkblatt für die Bevölkerung
Iodmerkblatt 2: Merkblatt für Ärzte

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Iodine Instruction Sheet 1: Instruction sheet for the population

Radiation accidents with release of radioactive iodine:

If accidents occur in nuclear facilities, especially in nuclear power plants, there may in unfavourable circumstances be a release of radioactive substances – including radioactive iodine – that makes it necessary to take countermeasures. Radioactive iodine has the same chemical and biological properties as the natural iodine that occurs in our food, and it is therefore stored in the thyroid gland in the same way as normal, non-radioactive iodine. This concentrated storage in the thyroid gland makes iodine different from other substances.

How does radioactive iodine enter the body?

Like other substances from the environment, radioactive iodine can enter the human body (incorporation) in three ways:

1. with air via the respiratory tract,
2. with food and drink via stomach and intestines (ingestion), and
3. via the skin following contamination.

Uptake via the skin is usually so minimal that it can be disregarded. Intake with water or food may be considerable, e.g. if milk is drunk that comes from cows that have been grazing on grass contaminated with radioactive iodine. This intake, however, is very easy to prevent following a nuclear accident: such milk, or vegetables from areas on which radioactive iodine has been deposited, are withheld from immediate consumption. A warning by the emergency control management against consuming specific foods from specific areas, and compliance with this warning, is sufficient to prevent this kind of intake of radioactive iodine.

Where there is radioactive iodine in the air we breathe, it is not possible to prevent its intake entirely, even by staying indoors. Taking iodine tablets reduces the effect of radioactive iodine in the body by ensuring that it is excreted as quickly as possible.

How do iodine tablets work?

In order to function properly, the thyroid gland needs small quantities of iodine which are normally present in the food we eat. Since Germany is an iodine-deficient region, adequate supplies cannot be guaranteed from our normal food intake. For this reason it is generally recommended that iodine-deficiency diseases be prevented by using iodine-enriched salt or taking tablets with a low iodine content (0.1 to 0.2 mg); these tablets, however, are not suitable for iodine saturation prophylaxis.

Only iodine tablets with one thousand times this dose (100 mg iodide) are suitable for saturation purposes, since they prevent the uptake of radioactive iodine by the thyroid. The surplus iodine is quickly excreted from the body.

Why take iodine tablets as a preventive measure?

It must be stressed that taking iodine tablets provides protection against the effects of radioactive iodine only, and not against the effects of other radioactive substances. This protection is most effective if the tablets are taken shortly before or practically at the same time as the radioactive iodine is inhaled. A certain protection is nevertheless achieved even a few hours after inhaling radioactive iodine. More than a day after the intake of radioactive iodine, taking iodine tablets no longer provides any protection; indeed, it is more likely to be harmful. The same applies to taking iodine tablets too early.

Where and when are iodine tablets obtainable if needed?

The competent authorities have laid in adequate stocks of iodine tablets and have stored them so that if need be they can be issued without delay to the affected population, except where they have already been distributed to households meeting certain criteria. „If need be“ means that – depending on how an accident situation develops – it might become advisable to take iodine tablets. Their distribution is a precautionary measure and does not mean that the tablets should be taken immediately. Should it in fact become necessary to take them, the emergency control authority will expressly request the affected population to do so by means of announcements over the radio or public address systems, for example.

Since only the authorities, in the light of their assessment of the accident situation, can decide whether it is necessary to take iodine tablets, the public should never take the tablets on their own initiative or as a result of anxiety.

Composition of tablets for iodine prophylaxis:

One tablet contains 130 mg potassium iodide (KI), corresponding to 100 mg iodide.

Effects and reason for use:

In the specified doses and if taken at the specified time, the iodine tablets saturate the thyroid with iodine and thereby prevent it from storing radioactive iodine (iodine prophylaxis). Iodine tablets of this kind are not suitable for compensating the iodine deficiency prevailing in Germany.

Dosage:

- Individuals aged 13 to 45 years take a single dose of 1 tablet.
- Children aged 3 to 12 years take a single dose of $\frac{1}{2}$ tablet.
- Infants aged 1 to 36 months take a single dose of $\frac{1}{4}$ tablet.
- Neonates up to one month take a single dose of $\frac{1}{8}$ tablet.

The iodine tablets should preferably not be taken on an empty stomach. Taking them can be made easier – especially for children – by dissolving the tablet in a drink, e.g. water or tea.

The solution does not keep, however, and must be drunk immediately. For neonates aged up to one month, a quarter of a tablet should be dissolved in tea and only half the solution should be administered; the rest should be thrown away.

Iodine tablets are only to be taken when so directed by the competent authority. Pregnant women and breast-feeding mothers are to receive the same iodine dose as the 13 to 45 age group. Adults aged over 45 should not take any iodine tablets, as the health risk of serious thyroid disorders (e.g. iodine-induced hyperthyroidism) as a result of taking the tablets is greater than the radiation risk from breathing radioactive iodine.

As a rule, a single dose of the iodine tablets should be sufficient. In exceptional cases the competent authority may recommend taking an additional tablet. The number of tablets issued is adequate for this purpose. In neonates younger than one month the administration of iodine should be confined to a single dose.

Iodine tablets during pregnancy:

The recommended iodine prophylaxis should be used during pregnancy as well, because taking iodine protects both mother and unborn child. The pregnant woman should however inform her doctor that she has taken iodine tablets, as the doctor will then pay special attention to the routine thyroid check on the new-born child.

Incompatibility and risks:

Persons with a known hypersensitivity to iodine (very rare disorders such as genuine iodine allergy, dermatitis herpetiformes Dühring, iododerma tuberosum, hypocomplementaemic vasculitis, myotonia congenita) must not take iodine tablets. In rare cases iodine tablets may also lead to skin rashes, oedema, sore throat, watering eyes, nasal catarrh, swelling of the salivary glands and elevated temperature.

Persons up to age 45:

Persons aged up to 45 who suffer or have suffered from overactivity of the thyroid gland should take iodine tablets while continuing with their treatment, but should consult their doctor after the end of the emergency situation.

In patients aged up to 45 who are suffering from hyperthyroidism or a nodular alteration of the thyroid, the risk of a deterioration in their condition or of triggering overactivity of the thyroid is increased. They should therefore visit their doctor as soon as possible after taking iodine tablets.

Persons who between one week and three months after taking iodine tablets notice symptoms that suggest overactivity of the thyroid, such as anxiety states, palpitations, weight loss or diarrhoea, should also consult their doctor.

Persons aged over 45:

Since, owing to the general iodine deficiency in Germany, early forms of thyroid overactivity (so-called functional autonomy or „hot nodules“) are common in persons aged over 45, the risk after taking iodine tablets (deterioration in the metabolic situation) outweighs the

radiation risk due to radioactive iodine, which is very low in this age group, so they are recommended not to take iodine tablets.

Side effects:

Taking iodine tablets may cause a metallic taste in the mouth. In isolated cases temporary stomach problems may occur. If the symptoms last for any length of time a doctor should be consulted.

What do iodine tablets not protect against?

Iodine tablets do not provide protection against radiation from outside the body, nor against radioactive substances other than iodine that have been absorbed by the body.

Urgent request:

In your own interests you should therefore follow the instructions given by the authorities, since they are in a position to judge the overall situation and will order further appropriate protective measures.

Note:

The tablets – like other pharmaceutical products – must be protected from light and moisture.

<p>In view of the possible side effects, iodine tablets should only be taken by persons under 45 years of age and only when directed by the authorities.</p>

Iodine Instruction Sheet 2: Instruction sheet for doctors

Preliminary remarks:

The authorities responsible for emergency control keep stocks of iodine tablets so that they can issue them to the population if the need arises, except where they have already been issued to households meeting certain criteria. One tablet contains 130 mg potassium iodide (KI), corresponding to 100 mg iodide. This instruction sheet is intended to inform the doctor about the main problems associated with iodine saturation of the thyroid. In this connection, attention is also drawn to the Instruction Sheet for the Public on the Use of Iodine Tablets for Thyroid Saturation following a Nuclear Accident.

Why saturate the thyroid?

Among the fission products created during the operation of nuclear reactors are the various radioactive isotopes of iodine. Because of the special biological feature of iodine, namely its incorporation in the thyroid hormones, these isotopes are of special importance. Since the temperatures in nuclear reactors are such that the iodine is present in gaseous form, it is possible that in the event of an accident, radioactive iodine may in unfavourable circumstances be released into the air. The greater part of this radioactive iodine will be deposited on the ground and on plants. From here it may be absorbed by humans by way of foodstuffs, and in particular through milk.

After a nuclear accident, radioactive iodine may be inhaled with the air and absorbed by the lungs. After absorption, the radioactive iodine behaves in exactly the same way as stable iodine.

Dispersion in the extravascular area is followed by a temporary concentration in the salivary glands and the mucous membrane of the stomach and, in particular, by a long-lasting accumulation in the thyroid. The extent of the accumulation in the thyroid depends on the functional state of that organ and, in the case of euthyroidism, especially on the iodine supply in the diet. The lower the amount of iodine in the diet, the higher the percentage accumulated in the thyroid. In the Federal Republic of Germany, which is an iodine-deficient region, the daily intake of iodine from foodstuffs is generally less than 70 µg, and in the case of euthyroidism more than 50 % of the radioactive iodine absorbed is accumulated in the thyroid. In countries with adequate supplies of iodine the absorption of radioactive iodine is lower by a factor of 2 to 3.

The purpose of iodine prophylaxis is to prevent radiation-induced thyroid carcinomas. Children are specially at risk.

When is iodine prophylaxis indicated?

Saturation of the thyroid with iodine can only be considered if the assessment of the situation indicates that there is a genuine risk of a substantial release of radioactive iodine. Following the Chernobyl reactor disaster, incorporation of iodine resulted in sometimes high thyroid doses. This was especially the case in children under 4 years old; the main focus when implementing iodine prophylaxis should therefore be on providing protection for children.

A release of radioactive iodine on a scale suggesting a need for iodine prophylaxis for the population will usually be identified in good time. One can therefore expect a warning period ranging from hours to days, during which the authorities can give the necessary instructions based on the information available to them and their judgement of the situation.

It is necessary to stress to patients that it would be useless and even harmful for them to embark on iodine prophylaxis on their own, i.e. without being requested to by the authorities. This would merely expose them unnecessarily to the risk of side effects.

Is thyroid prophylaxis permissible for pregnant women and nursing mothers?

In foetuses, iodine is taken up by the thyroid from about the 12th week of pregnancy onwards. From the 6th to 9th month, iodine storage in the foetal thyroid is considerable. There is thus a need for saturation of the thyroid in older foetuses, and this takes place through the administration of iodine to the pregnant woman without the need for any special dose adjustment.

Occasionally, the sensitive foetal thyroid may develop a goitre with hypothyroidism. This hypothyroidism is identified by the routine TSH screening on the fifth day after birth and treated accordingly.

During lactation, iodine is present in the mother's milk in individually varying quantities. Since this does not guarantee adequate iodine prophylaxis for breast-fed babies, iodine tablets should also be given to neonates and breast-fed babies (see dosage scale).

Women who have been treated with large doses of iodine during pregnancy and lactation should be urged to point this out to the obstetrician and paediatrician so that they can make a particularly careful check for any functional disorders of the thyroid.

How is the thyroid blocked against radioactive iodine?

Accumulation of radioactive iodine in the thyroid can be prevented by administering a considerable quantity of stable (non-radioactive) iodide in large individual doses (around 100 mg) before the intake of radioactive iodine takes place. As a result of this increased supply of stable iodine in conjunction with the limited uptake capacity of the thyroid, only a small fraction of the radioactive iodine absorbed by the body is stored in the thyroid. The iodine not stored is excreted from the body with a biological half-life of approximately 6 hours.

Since the accumulation curve is initially very steep, iodine blockage is most effective if the stable iodine is already present in the system shortly before the radioactive iodine is absorbed. However, a reduction in the amount accumulated is still achieved in the first few hours after intake of radioactive iodine (iodine taken one hour later – reduction by about 80 percent; iodine taken two hours later – reduction by about 50 percent). By contrast, administering stable iodine later than 8 hours after inhalation or ingestion of radioactive iodine no longer has any appreciable influence on this accumulation nor, consequently, on the radiation exposure of the thyroid due to radioactive iodine. If large doses of stable iodine are given later than 24 hours after incorporation, this actually increases the time the radioactive iodine is retained in the body. Iodine tablets should therefore not be taken after this point in time.

What should be the dose of potassium iodide?

Not only the timing of administration, but also the quantity of stable iodine is of crucial importance in minimising the accumulation of radioactive iodine. Since it is important that the blockage be as total as possible, a high plasma concentration of stable iodine must be achieved initially. In adults this is achieved with a dose of 130 mg potassium iodide; this does not generally involve any risk of intolerant response by the stomach, provided the pills are not taken on an empty stomach.

Reducing the dose does not bring any reduction in side effects; increasing it would not be harmful, but does not result in any appreciable reduction in radiation exposure.

Group of persons	Daily dose in mg iodide	Daily dose in mg potassium iodide	Tablets of 130 mg potassium iodide
< 1 month	12.5	16.25	$\frac{1}{8}$
1 - 36 months	25	32.5	$\frac{1}{4}$
3 - 12 years	50	65	$\frac{1}{2}$
13 - 45 years	100	130	1
> 45 years	0	0	0

Iodine tablets are only to be taken when instructed by the competent authority. Pregnant women and breast-feeding mothers receive the same iodine dose as the 13 - 45 age group. As a rule it is sufficient to take a single dose of iodine tablets. In exceptional cases, however, the competent authority may recommend taking an additional dose. For new-born children younger than one month the intake should however be confined to one day.

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The iodine tablets should preferably not be taken on an empty stomach. Taking them can be made easier – especially for children – by dissolving the tablet in a drink, e.g. water or tea. The solution does not keep, however, and must be drunk immediately. For neonates aged up to one month, a quarter of a tablet should be dissolved in tea and only half the solution should be administered; the rest should be thrown away.

What health risks are involved in iodine saturation of the thyroid?

Persons with a known hypersensitivity to iodine (very rare disorders such as genuine iodine allergy, dermatitis herpetiformes Duhring, iododerma tuberosum, hypocomplementaemic vasculitis, myotonia congenita) must not take iodine tablets. In rare cases iodine tablets may also lead to skin rashes, oedema, sore throat, watering eyes, nasal catarrh, swelling of the salivary glands and elevated temperature.

In very rare cases, signs of hypersensitivity to iodine (genuine iodine allergy), e.g. iodic rhinorrhea or iodic rash, may be observed. However, the possibility of intolerance to iodine should not be overrated. Absorption of iodine by the body can be inhibited by gastric irrigation with starch solution (30 g to 1 litre until blue colour disappears) or with a 1-3 % solution of sodium thiosulphate. Administration of Glauber's salts and forced diuresis are recommended to speed up excretion. Any shock and any water and electrolyte disorders are to be treated in the usual way.

In cases of a previous history of thyroid disorder, even if its course has so far been asymptomatic (especially in cases of nodular goitre with functional autonomy), hyperthyroidism may be triggered within weeks or months after administration of iodine.

Conversely, neonates and infants are especially susceptible to hypothyroidism if iodine is administered for longer periods of time.

Owing to the low risk of carcinoma induction by radioactive iodine in older individuals and the rising incidence of pathological functional autonomy with increasing age, iodine prophylaxis should not be given to persons over 45 years of age.

Induction of hyperthyroidism:

A healthy thyroid has several regulatory mechanisms that enable it to tolerate an excess supply of iodine without any harmful increase in production of thyroid hormones. The pathological mechanism by which an elevated supply of iodine results in clinically manifest thyroidism is not yet fully understood. It is however known that this transition to hyperthyroidism occurs mainly in areas where goitre is endemic with a high prevalence of functional autonomy.

This possibility of triggering hyperthyroidism therefore has to be expected in the Federal Republic of Germany if iodine intakes are high.

The following are possible bases for the development of hyperthyroidism:

1. Autoimmune hyperthyroidism (Basedow's disease),
2. Functional autonomy
 - unifocal/multifocal („autonomous adenoma“),
 - disseminated.

All three disorders of the thyroid may also exist as latent disorders without displaying any clinical symptoms of hyperthyroidism.

Contra-indications for thyroid prophylaxis

Unfounded contra-indications occasionally found in the literature are cardiac insufficiency and the various forms of tuberculosis. Pregnancy and lactation, as well as hyperthyroidism and thyroiditis, are also mentioned but are not contra-indications.

Iodine should not be administered if there is a known iodine allergy. This should not be confused with an intolerant response or allergy to X-ray contrast media, which in most cases is not due to the iodine they contain.

Patients suffering from certain very rare diseases – genuine iodine allergy, dermatitis herpetiformis Duhring, iododerma tuberosum, hypocomplementaemic vasculitis, myotonia congenita – must not take iodine in any circumstances.

Patients undergoing treatment for hyperthyroidism must continue their treatment alongside the intake of iodine. All patients suffering from hyperthyroidism – whether or not undergoing treatment – must be monitored by a doctor with hormone analyses at frequent intervals after the end of an emergency involving iodine prophylaxis.

Other medication that can be used to block the thyroid:

Since the aim of iodine prophylaxis is to prevent the accumulation of radioactive iodine in the thyroid as far as possible, the most suitable medication apart from iodine is perchlorate, which competitively inhibits the uptake of iodine, e.g. potassium perchlorate as Irenat[®].

The following dosage is recommended for adults:

Sodium perchlorate as Irenat[®]:
– on first day 60 drops,
thereafter 15 drops every 6 hours for seven days.

Contra-indications such as hypersensitive reactions (agranulocytosis) and serious liver damage must be observed.

Since iodine blockage with iodide is more effective than with perchlorate, the latter should only be used if large doses of iodine are contra-indicated.