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Use of Iodine Tablets for Thyroid Blocking in the Event of a Nuclear Accident

Recommendation of the German Commission on Radiological Protection

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1 Recommendation and background

As part of its new information strategy concerning the use of iodine for thyroid blocking as an emergency response measure, the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) requested the SSK to review the iodine information leaflets which were last published in 2004.

The review revealed a need for only minor changes to both the leaflet for doctors and pharmacists and the leaflet for the general public.

In the past Germany was regarded as an iodine deficiency area. However, thanks to factors such as the use of iodised table salt, the situation has improved significantly in recent decades, as increased iodine excretion and the lower incidence of thyroid autonomy show. The distribution of iodine deficiency is no longer a regional issue but is determined by nutrition habits. The frequency of thyroid disorders has shifted to higher age groups. The SSK recommends removing references to iodine deficiency from the iodine leaflets.

It was previously recommended that iodine tablets for the purpose of thyroid blocking should not be given to people over 45, since in their case the risk of side effects is higher than the risk of developing thyroid cancer at a later date. The SSK recommends retaining this age limit until further notice, since the thyroid status of older people has not yet changed as markedly as that of younger people.

The SSK continues to recommend that people who have been or are being treated for an overactive thyroid (hyperthyroidism) should consult the doctor who is treating them before taking iodine tablets.

The previous reference to the occasional occurrence of goitre in newborns can be removed, since it is not relevant to thyroid blocking with iodine.

As regards the frequency of tablet intake, the iodine information leaflets of 2004 stated that a one-off dose is normally sufficient. In exceptional cases the responsible authorities would recommend a second intake of tablets. The conditions under which a second intake of tablets should take place are described in more detail in the updated iodine information leaflets.

If the release of radioactive iodine persists (for several days or weeks) and thyroid blocking can no longer be assured by the one-off intake of inactive iodine, the absorption of radioactive iodine by the thyroid can be limited by taking additional inactive iodine. The inactive iodine is then present in the body in larger quantities than the radioactive iodine. If the intake of iodine tablets has already been recommended because of an acute risk of iodine release but the actual iodine release occurs very much later (days later), a further intake of iodine tablets could likewise be recommended.

Since the decrease of iodine in the thyroid depends on thyroid status and hence on the iodine supply and in addition varies widely between individuals, it is not possible to provide simple rules for a second administration of iodine. The authorities responsible for the decision to recommend the taking of iodine tablets should seek the advice of doctors with specialist knowledge in this area. The SSK recommends that the responsible authorities include the contact details of such doctors in their plans.

The SSK recommends that the authorities responsible for planning thyroid blocking provide doctors and pharmacists in potential distribution areas with the iodine information leaflets and information on thyroid blocking in advance – e.g. via the website www.jodblockade.de. Doctors can then discuss with their patients before an event occurs the action that they as individuals should take if thyroid blocking with iodine becomes necessary. The SSK continues to recommend that the subject of thyroid blocking should be addressed as part of doctors' medical training.

2 Information leaflet for doctors and pharmacists

Preliminary notes

The authorities responsible for civil protection maintain a stock of potassium iodide tablets (referred to in the following as iodine tablets) that can be distributed to the public when needed if they have not already been distributed to households under particular conditions. One tablet contains 65 mg potassium iodide (KI), which is equivalent to 50 mg iodide. This leaflet is intended to inform doctors about the key issues associated with thyroid blocking. A separate information leaflet is provided for the general public.

Why thyroid blocking?

The fission products produced by nuclear reactors include the various radioactive isotopes of iodine. Because iodine is biologically active – it is incorporated into the thyroid hormones – these isotopes are of special significance. At the temperatures found in nuclear reactors iodine occurs in a gaseous state; it must therefore be assumed that in the event of an accident in unfavourable circumstances radioactive iodine will be released into the air. Most of this radioactive iodine will be deposited on the ground and on vegetation. From there humans may ingest it with food, especially milk. In a nuclear accident iodine may also be inhaled from the air and resorbed into the lungs.

After absorption the radioactive iodine behaves in exactly the same way as stable iodine. The iodine enters the extravascular space; this leads to temporary accumulation of iodine in the salivary glands and the gastric mucosa and to long-term storage of iodine in the thyroid. The extent of this storage depends on the functional status of the thyroid and in particular – in euthyroid people – on the amount of iodine in the diet. The lower the amount of iodine in the diet, the higher the percentage of iodine that is stored in the thyroid.

The aim of thyroid blocking is to prevent radiation-induced thyroid carcinomas. Children are particularly at risk.

When is thyroid blocking indicated?

thyroid blocking should only be considered when it appears likely from an assessment of the situation that a significant release of radioactive iodine will actually occur. Especially in children under the age of four, incorporation of radioactive iodine can result in high doses to the thyroid. The protection of children and pregnant women should therefore be a priority of thyroid blocking.

A release of radioactive iodine in a quantity that justifies thyroid blocking for the population is normally detected promptly. There is therefore likely to be an early-warning period of hours or days during which the authorities can issue the necessary instructions, based on the information available to them and the assessment of the situation.

It is necessary to inform the population that it is pointless and may even be harmful for people to undertake thyroid blocking on their own initiative, i.e. without being instructed by the responsible authorities to do so. They would only be exposing themselves unnecessarily to the risk of side effects.

Is thyroid blocking permissible for pregnant and nursing women?

The recommended thyroid blocking should also be implemented during pregnancy, irrespective of the age of the pregnant woman.

The foetus absorbs iodine into the thyroid from about the twelfth week of pregnancy. From the sixth to the ninth month there is significant storage of iodine in the foetal thyroid. Thyroid blocking is therefore necessary for the older foetus; this is achieved via administration of iodine to the pregnant woman – there is no need for special adaptation of the dosage.

During lactation iodine is secreted in the mother's milk in quantities that vary from person to person. Since this does not ensure a sufficient thyroid blocking for the breastfed child, newborns and infants should also be given iodine tablets (see dosing schedule).

Women treated with high doses of iodine during pregnancy and lactation should be instructed to inform their midwife and paediatrician of this so that these health care professionals are alert to the possibility of thyroid dysfunction in the newborn.

How is thyroid blocking to radioactive iodine carried out?

Storage of radioactive iodine in the thyroid can be prevented by administering a relatively large amount of stable (non-radioactive) iodide in a high single dose (between 12.5 and 100 mg depending on age) before absorption of radioactive iodine takes place. Because of the thyroid's limited uptake capacity, this increased supply of stable iodine means that only a small percentage of the absorbed radioactive iodine is stored. The iodine that is not stored in the thyroid is excreted with a biological half-life of several hours. The biological half-life of iodine in the thyroid depends on the hormone turnover; it is usually between three and 60 days.

Since the thyroid's storage curve is initially very steep, thyroid blocking is most effective when the stable iodine is present in the organism shortly before absorption of the radioactive iodine takes place. However, a reduction in storage can still be achieved in the hours immediately following exposure to radioactive iodine (iodine administration after two hours – reduction of approx. 80%; iodine administration after eight hours – reduction of approx. 40%). By contrast, the administration of stable iodine more than 24 hours after the conclusion of absorption has no significant influence on storage and hence does not prevent radiation damage to the thyroid by the radioactive iodine. If high doses of stable iodine are taken significantly more than 24 hours after incorporation, this actually prolongs retention of the radioactive iodine. Iodine tablets should therefore not be taken after this 24-hour period.

What dosage of potassium iodide should be taken?

As well as the timing of administration, the quantity of stable iodine is also crucial if the storage of radioactive iodine is to be reduced. Since it is important for the blocking to be as complete as possible, a high plasma concentration of stable iodide is first required. In adults this is achieved by a 130 mg dose of potassium iodide. Provided that this is not taken on an empty stomach, this is generally unlikely to cause stomach upsets.

A reduction of the dose does not reduce possible side effects; an increase would not be harmful but achieves no noticeable additional reduction in radiation exposure.

The following dosing schedule is recommended:

These dosages apply only to the 65-mg potassium iodide tablets from the emergency stocks

Age group	One-day dose in mg iodide	One-day dose in mg potassium iodide	65-mg potassium iodide tablets
< 1 month	12.5	16.25	1/4
1-36 months	25	32.5	1/2
3-12 years	50	65	1
13-45 years	100	130	2
> 45 years	0	0	0

(For tablets with a different potassium iodide content please consult the dosage instructions supplied with them.)

Pregnant and nursing women should receive the same dose as individuals in the 13-45 age group.

Wherever possible, potassium iodide should not be taken on an empty stomach. The tablets can be swallowed or dissolved in liquid which is then drunk. Administration of the tablet to infants and children can be facilitated by dissolving it in a drink, such as water or tea. However, the solution does not keep and must be drunk immediately.

Iodine tablets should only be taken on the instructions of the responsible authorities. If necessary the authorities will specify in their instructions which groups of individuals should take the tablets.

A one-off intake of iodine tablets is normally sufficient. Depending on the radiological situation, the responsible authorities may under certain conditions (e.g. persistent release of iodine or intake of iodine tablets but delayed release) recommend a second intake of tablets.

In the case of pregnant and nursing women and newborns, other measures should be taken to ensure that a second intake of iodine tablets is not required.

What are the health risks of thyroid blocking?

Individuals with a known hypersensitivity to iodine (in very rare conditions such as genuine iodine allergy, dermatitis herpetiformis [Duhring's disease], iododerma tuberosum, hypocomplementemic vasculitis, myotonia congenita) should not take iodine tablets. Occasionally iodine tablets may also cause skin eruptions, sore throat, watery eyes, catarrh, swelling of the salivary glands or fever.

Very rarely there may be signs of hypersensitivity to iodine (genuine iodine allergy), e.g. iodine catarrh or iodine rash. The possibility of iodine intolerance should not be overrated. Iodine resorption can be inhibited by irrigating the stomach with starch solution (30 g to 1 litre, until the blue colour disappears) or 1 – 3% sodium thiosulphate solution. To accelerate excretion, administration of Glauber's salt and forced diuresis are recommended. If shock or fluid and electrolyte imbalances occur, they should be treated in the usual way.

In the event of pre-existing thyroid disorders, even if previously asymptomatic (and especially in the case of nodular goitres with functional autonomy), hyperthyroidism may be triggered within weeks or months of iodine intake.

By contrast, administration of iodine over a long period may lead to hypothyroidism, especially in newborns and infants.

Because there is a slight risk of radioactive iodine causing cancer in older people and a higher risk of pathologically significant functional autonomies with increasing age, thyroid blocking should not be administered to people over the age of 45.

Triggering hyperthyroidism:

A healthy thyroid gland has a number of regulatory mechanisms that enable it to tolerate an oversupply of iodine or a harmful increase in the production of thyroid hormones. The pathophysiology of clinically manifest hyperthyroidism as a result of an increased supply of iodine is not yet fully understood. It is, however, known that this transition to hyperthyroidism occurs mainly in areas where goitre is endemic and there is a high prevalence of functional autonomy.

If the iodine supply in Germany is increased, the possibility of hyperthyroidism being triggered must therefore be borne in mind.

Hyperthyroidism may occur as a result of:

1. autoimmune hyperthyroidism (Graves' diseases, Basedow's syndrome),

2. functional autonomy
   – unifocal/multifocal (autonomous adenoma),
   – disseminated.

All three thyroid disorders can also occur in latent form with no clinical signs of hyperthyroidism.

When is thyroid blocking contraindicated?

Contraindications occasionally referred to in the literature, although unsubstantiated, are coronary insufficiency and tuberculosis in its various forms. Both pregnancy/lactation and hypothyroidism/thyroiditis are also mentioned, but these are not contraindications.

Iodine should not be administered in cases of known iodine allergy. This must not be confused with an intolerance reaction or an allergy to x-ray contrast agents, which is usually not caused by the iodine in the agent.

In no circumstances should iodine be administered to patients with the very rare conditions of genuine iodine allergy, dermatitis herpetiformis (Duhring's disease), iododerma tuberosum, hypocomplementemic vasculitis or myotonia congenita.

Patients receiving treatment for hyperthyroidism should consult their doctor before taking iodine tablets. Once an emergency situation involving iodine administration has ended, doctors should monitor all hyperthyroid patients – whether in treatment or not – by carrying out hormone analysis at frequent intervals.

Options for thyroid blocking using other medication

A blocking to prevent the storage of radioactive iodine in the thyroid should be as complete as possible. Therefore the most suitable alternative to iodine is perchlorate, which competitively inhibits the uptake of iodine, e.g. sodium perchlorate as Irenat$^{(R)}$.

Since thyroid blocking is more effective with iodide than with perchlorate, the latter should only be used if high doses of iodine (100 mg iodide) are contraindicated.

The following dosage is recommended for adults:

Sodium perchlorate as Irenat$^{(R)}$
– **initially 60 drops,**
thereafter 15 drops every 6 hours for 7 days.

Attention must be paid to contraindications such as hypersensitivity reactions (agranulocytosis) and severe liver disease.

3 Information leaflet for the general public

A nuclear accident involving release of radioactive iodine

In unfavourable circumstances, accidents in nuclear facilities, especially in nuclear power plants, may result in the release of radioactive substances, including radioactive iodine. Radioactive iodine has the same chemical and biological properties as the iodine that occurs naturally in food and is therefore stored in the thyroid gland in the same way as normal, non-radioactive iodine. This concentrated storage in the thyroid distinguishes iodine from other substances. Taking iodine tablets as a countermeasure (thyroid blocking) can prevent the radioactive iodine being stored.

How does radioactive iodine enter the body?

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

1. from the air via the respiratory system (inhalation),

2. with food and drink via the stomach and digestive system (ingestion) and

3. via the skin following contamination.

Absorption via the skin is usually so slight that it can be ignored. Absorption with water or food can be considerable – e.g. if milk is drunk from cows that have grazed on pasture contaminated with radioactive iodine. However, in the event of a radiation accident this type of absorption can be very easily prevented: such milk, or vegetables grown on land on which radioactive iodine may have been deposited, should be withdrawn from direct consumption.

The absorption of radioactive iodine through inhalation is only slightly reduced by remaining indoors. Taking iodine tablets reduces the effect of the radioactive iodine on the body by ensuring that it is excreted as quickly as possible.

How do iodine tablets work?

To function normally the thyroid gland needs small amounts of iodine, which are usually absorbed with food. This is why the use of iodised table salt or low-dose iodine tablets (0.1 – 0.2 mg) is recommended as a general means of preventing iodine deficiency disorders. However, these tablets are not suitable for a thyroid blocking.

Thyroid blocking requires tablets containing a significantly higher dose of iodine, since they prevent radioactive iodine being absorbed into the thyroid. The excess iodine is quickly excreted from the body.

Why is the preventive intake of iodine tablets necessary?

It must be emphasised that taking iodine tablets provides protection only against the absorption of radioactive iodine by the thyroid; it provides no protection against the effects of other radioactive substances. Protection is most effective when the iodine tablets are taken shortly before or virtually simultaneously with the inhalation of radioactive iodine. However,

taking tablets a few hours after inhaling radioactive iodine still provides some protection. The intake of tablets more than 24 hours after the absorption of radioactive iodine no longer provides any protection; indeed, it is then more harmful than protective. Taking tablets too early is likewise ineffective.

Where and when can iodine tablets be obtained when needed?

The responsible authorities have adequate stocks of iodine tablets available for immediate distribution to the affected population in case of need, provided that they have not already been distributed to households under particular conditions. "In case of need" in this context means a situation in which – depending on developments following an accident – the intake of iodine tablets is to be recommended.

The distribution of iodine tablets is a precautionary measure and does not mean that the tablets should be taken immediately. If it should actually become necessary to take the tablets, the responsible authorities will expressly direct the affected population – e.g. via radio or loudspeaker announcements – to do so.

Only the authorities can decide whether the intake of iodine tablets is necessary, on the basis of the assessment of the accident situation. You should never take the tablets on your own initiative or because of your own fears.

Composition of the tablets used for thyroid blocking:

One tablet from Germany's emergency stocks contains 65 mg potassium iodide, which is equivalent to 50 mg iodide.

Tablets containing 130 mg potassium iodide, equivalent to 100 mg iodide, may also be available from pharmacies.

Effects and purpose of use:

When taken in the specified dose and at the recommended time, the iodine tablets saturate the thyroid with iodine and hence prevent it from storing radioactive iodine ("thyroid blocking "). Iodine tablets of this type are not suitable for iodine substitution. Any medical treatment with iodine should be continued.

Dosage

The following dosage applies only to 65-mg potassium iodide tablets (e.g. from the emergency stocks).

People aged between 13 and 45 should take a one-off dose of 2 tablets. Children between the ages of 3 and 12 should take a one-off dose of 1 tablet. Infants aged between 1 and 36 months should receive a one-off dose of ½ tablet. Babies less than 1 month old should be given a one-off dose of ¼ tablet.

(For tablets of different potassium iodide content please consult the dosage instructions supplied with them.)

Pregnant and nursing women should receive the same dose of iodine as people in the 13-45 age group. Adults over 45 should not take iodine tablets, since for them the risk of serious thyroid disorders (e.g. overactivity of the thyroid caused by iodine) as a result of taking the tablets is greater than the radiation risk from the inhalation of radioactive iodine.

Where possible the iodine tablets should not be taken on an empty stomach. The tablets can be swallowed, or they can be dissolved in liquid before taking. Giving the tablet to infants and children can be made easier by dissolving it in a drink, such as water or tea. However, the solution does not keep and must be drunk immediately.

Iodine tablets should only be taken on the instructions of the responsible authorities. If necessary the authorities will specify in their instructions which groups of individuals should take the tablets.

A one-off intake of iodine tablets is normally sufficient. A further intake of tablets should only be undertaken if this is recommended by the responsible authorities.

Iodine tablets in pregnancy:

The recommended thyroid blocking should also be carried out in pregnancy, irrespective of the age of the pregnant woman, since the intake of iodine protects both the mother and the unborn child. The pregnant woman should, however, inform her doctor that she has taken iodine: the doctor will then ensure that the routine monitoring of the newborn's thyroid function is conducted with particular thoroughness.

Intolerance and risks:

Iodine tablets should not be taken by persons who have:

– a known hypersensitivity to iodine (this is very rare and should not be confused with the commonly occurring allergy to x-ray contrast agents),

– dermatitis herpetiformis (Duhring's disease),

– hypocomplementemic vasculitis (allergic inflammation of the blood vessel walls).

Occasionally, taking iodine tablets may also cause allergic reactions such as skin rashes, oedema, sore throat, watery eyes, catarrh, swelling of the salivary glands, fever or other symptoms.

Persons who have ever been diagnosed with an overactive thyroid should consult their doctor before taking iodine tablets. In patients with an overactive thyroid or nodular changes in the thyroid, there is an increased risk that iodine tablets may cause their condition to deteriorate or trigger hyperthyroidism. Such persons should therefore consult a doctor soon after taking the tablet.

A doctor should also be consulted if symptoms that could indicate an overactive thyroid appear between one week and three months after taking the tablets. Such symptoms include agitation, palpitations, weight loss and diarrhoea.

People over the age of 45:

There are two reasons why thyroid blocking with iodine is **not** recommended for people over the age of 45:

1. Metabolic disorders of the thyroid become more common with increasing age. These disorders, known as functional autonomies, increase the risk of side effects from thyroid blocking with iodine.

2. The risk of a malignant thyroid tumour caused by exposure to radiation declines sharply with increasing age.

Side effects:

Irritation of the stomach lining can occur, especially if the iodine tablets are taken on an empty stomach. If symptoms persist a doctor should be consulted.

What do iodine tablets not protect against?

Iodine tablets provide no protection against radiation from outside the body, or against the effects of radioactive substances other than iodine that may be absorbed into the body.

Very important:

It is in your own interest to follow the instructions of the authorities, since they can assess the situation and issue directions for other appropriate protective measures.

Note:

Like all medicines, the tablets should be stored away from light and moisture and kept out of the reach of children.

Because of the possible side effects, iodine tablets should be taken only upon the specific instructions of the responsible authorities. People over 45 should not take the tablets. This age limit does not apply to pregnant women.