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Review

Iodine Kinetics and Effectiveness of Stable Iodine Prophylaxis After Intake of Radioactive Iodine: A Review

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Ingestion of potassium iodide (KI) offers effective protection against irradiation of the thyroid after accidental exposure to radioactive iodine. This prophylaxis aims at rapidly obtaining maximal thyroid protection without adverse effects. This article reviews studies on iodine kinetics in humans and on the efficacy of KI in protecting the thyroid. In adults with normal thyroid function, ingestion of 100 mg of iodide just before exposure to radioactive iodine blocks at least 95% of the thyroid dose. If exposure persists after iodide ingestion (100 mg), the percentage of averted dose may decrease significantly. Daily ingestion of a dose of 15 mg of KI would then maintain the thyroid blockade at a level above 90%. The efficacy of iodide and the occurrence of antithyroid effects also depend on external and individual factors such as dietary iodine intake, thyroid function, and age. The KI dosage regimen should be adjusted for age at exposure. For the fetus, the newborn, children, and adolescents, the risk of radiation-induced thyroid cancer in case of accidental exposure to radioactive iodine justifies KI prophylaxis, despite the risk of hypothyroidism, especially in newborns. For the elderly, the benefits of KI may be lower than the risk of iodine-induced hyperthyroidism.

Introduction

Oral administration of potassium iodide (KI) after radioactive iodine is accidentally released into the atmosphere is intended to limit, or even prevent, the uptake of this iodine by the thyroid gland and thus to reduce or avoid its irradiation. The thyroid gland is one of the organs most sensitive to radiation. Significant excess risks of thyroid cancer have been observed after external thyroid doses in children and adolescents (1,2). Since the Chernobyl accident, an unprecedented and very significant increase in the incidence of thyroid cancer among children and adolescents has been observed in Belarus, the Ukraine, and Russia. Release of radioactive iodine together with the absence of adequate thyroid protection are probably the main causes of this increase, although the role of other individual, as well as environmental, factors cannot be excluded (3). Conversely, an excess risk of thyroid cancer has not been demonstrated after medical irradiation of the adult thyroid at high doses of radioactive iodine, but it cannot be excluded (2).

Planning the use of this prophylaxis in the case of a radiological accident requires knowing its efficacy and the duration of its action as a function of individual characteristics and of the conditions of administration, as well as the nature and frequency of any adverse effects. This article reviews what is known about these questions and draws from this information conclusions for public health management.

After a brief review of the metabolism and kinetics of iodine in the body, we will present the results of studies about blocking thyroid uptake with KI. The adverse effects of KI prophylaxis will be presented and discussed, with special attention paid to the modifying effects of age.

Review of the Metabolism and Kinetics of Iodine

Iodine from food sources is absorbed in the digestive tract as iodide (I^-). Once in the bloodstream, it diffuses rapidly into the extracellular spaces, where it constitutes the body pool of extracellular iodine; it then follows two principal, competitive pathways: uptake by the thyroid gland or excretion in urine.

Intestinal absorption begins as soon as the iodine arrives in the stomach. In a fasting subject, radioactive tracer is observed in the neck approximately 3 minutes after oral administration of ^{131}I (4). Food in the stomach delays absorption by roughly 10 to 15 minutes (4–6). Absorption is com-

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plete in almost all subjects within a maximum of 2 hours after ingestion (5).

During a nuclear accident, inhalation may be the main exposure pathway for radioactive iodine. It is present in the plume in three principal forms (7): gaseous molecular iodine, gaseous organic iodine, and particulate iodine. Their respective proportions depend on the accident scenario and the relative importance of the pathways out of the containment.

Gaseous molecular iodine is deposited almost entirely in the upper respiratory-digestive tract; swallowed, it follows the metabolism of ingested iodine (8); blood absorption is rapid (10-minute half-life) and complete (9). For gaseous organic iodine, pulmonary retention is about 70% (10); it is absorbed into the blood very rapidly (5-second half-life) (9). Particulate iodine is present in aerosols: iodine incorporation is complete, regardless of particle size, because those that do not penetrate into the respiratory tract are swallowed and absorbed from the digestive system; blood absorption is rapid (10-minute half-life) (9).

Iodide uptake by the thyroid cells results from active transport mediated by the sodium iodide symporter (NIS) (11,12). This transport is the stage that limits iodine accumulation in the thyroid (13). At the apical membrane of the thyroid follicular cell, iodide is translocated into the colloid and organified, that is, oxidized and then combined with the tyrosine residues of thyroglobulin. This apical reaction involves pendrin, a chloride/iodide transporter (14), and thyroperoxidase. Iodine uptake and organification are stimulated by thyrotropin (TSH) (15). For a review of thyroid iodine transport see Spitzweg et al. (16).

After a single ingestion of radioactive iodine, thyroid uptake begins rapidly and then, in euthyroid subjects, reaches a plateau at 10% to 40% of the total iodine ingested in 24 to 48 hours (5,6). The time to reach half the total thyroid uptake varies from 3 to 6.5 hours (6), with substantial interindividual variation (17). Uptake varies proportionally to thyroid clearance and plasma iodide concentration (17).

Thyroid clearance depends on the volume and activity of the gland. It is adaptive and depends on plasma iodide concentration and dietary iodine intake. As a result, when dietary iodine intake is low, thyroid uptake increases (18–21); during exposure to radioactive iodine, the thyroid dose increases proportionally.

Thyroid uptake is higher in adolescents than adults and decreases progressively with age (22–29). Thyroid anomalies can modify thyroid uptake, which can increase substantially as, for example, in Graves' disease (4).

The kidney is the main pathway for iodine elimination (30). Renal excretion is rapid in the first hours, reaching a plateau at the end of 24 to 48 hours (4,5,17). Renal iodine clearance is not influenced by iodine intake: it is not adaptive and not saturable (13,17).

Urinary excretion is increased in pregnant women; this can result in a relative iodine deficiency (31). A compensatory increase in thyroid clearance is observed. The reduction in the quantity of iodine available to the mother worsens during the second half of the pregnancy because a fraction of the ingested iodine is taken up by the fetus and placenta. Iodine crosses the placental barrier (13). Iodine uptake by the fetal thyroid begins around 10 to 12 weeks (32–34) but remains low until 22 weeks. After that point, it increases rapidly until term (32). If the mother is exposed to radioactive iodine during this period, its concentration will be higher in the fetal than the maternal thyroid, because the fetus has a much lower iodine pool than the mother (35).

Iodine concentrates in maternal milk (13). Most of this iodine is excreted in the milk in the 48 hours after ingestion (36). When milk production is substantial, this is a major pathway for excretion. The transfer of iodine in mother's milk is saturable by an iodine overload (13).

Thyroid Blockade by KI

Mechanisms of KI action

With the exception of repeated TSH injections, no agent accelerates the elimination of radioactivity concentrated within the thyroid gland. Radioactivity persists there for several weeks and decreases slowly, as hormone secretion takes place (37).

Various antithyroid agents prevent the uptake of radioactive iodine by the gland (7). Of these, KI is effective and the least likely to induce side effects.

The uptake and organification of iodine by the thyroid increases proportionally with plasma concentration, with the ratio of thyroid iodine to plasma iodine remaining constant (13). The mechanisms of thyroid uptake blockade by a sudden iodine overload are described below.

Saturation and isotopic dilution. The phenomenon of saturation and isotopic dilution is the principal mechanism for the protective action of KI: it competes with radioactive iodine via the active iodine transport system in the thyroid. Nonetheless, radioactive iodine can still penetrate the gland by diffusion (38). KI also prevents the recycling of organic radioactive iodine into the thyroid and thus diminishes its effective half-life (39).

Inhibition of iodine organification and hormone synthesis. Above a plasma iodine concentration of 15 to 28 μg/dL, iodine organification diminishes rapidly, thereby entailing a reduction in hormone synthesis (13,40,41): this is known as the Wolff-Chaikoff effect, named for the scientists who observed it in rats in 1948. This process, which is not yet completely understood, is independent of TSH. It is thought to be determined by the reduction of the ratio of thyroid iodine to free iodine, in particular, by the substantial increase in the plasma iodine concentration (13,40).

The Wolff-Chaikoff effect is transient in a normal adult thyroid. It appears several hours after an excess dose of iodine, but iodine organification by the thyroid resumes within 24 to 48 hours, even if the iodine overload persists (escape) (41).

The inhibition of organification may play a complementary protective role by preventing the storage of organified radioactive iodine in the thyroid (42). It can also be more durable, however, and may then cause thyroidal side effects. In particular, this may occur when the thyroid iodine pool is low or thyroid iodine uptake is high before the overload (41).

The fetus is particularly sensitive to the Wolff-Chaikoff effect, because its thyroid iodine pool is low and its uptake high. The phenomenon of escape from the Wolff-Chaikoff effect appears late, only at around 36 weeks' gestation (41).

Inhibition of thyroid hormone secretion. The inhibition of thyroid hormone secretion, by inhibiting thyroglobulin hydrolysis, occurs rapidly at plasma concentrations lower than those that reduce hormone synthesis (41). This effect is transient and lasts no longer than 7 days (40). It is used in the treatment of acute hyperthyroidism.

Inhibition of thyroid hormone secretion could promote thyroid irradiation if the KI were ingested when radioactive iodine was already concentrated in the thyroid (7). Nonetheless, as the bulk of the radiation dose is delivered in the first days following exposure, it is improbable that this effect would have a significant impact on the radiation dose to the thyroid (13).

Review of the studies on thyroid blockade by KI

In the following studies, the dosage regimen of stable iodine is expressed either in total KI or in iodide alone (I^-): 130 mg of KI is equivalent to 100 mg of iodide. Most of the studies were carried out in adults.

Efficacy as a function of the amount of KI. Thyroid uptake was measured after oral administration of ^{131}I to euthyroid adults (43); the study population included 10 control subjects and 60 experimental subjects distributed into 10 groups receiving doses of KI ranging from 5 to 80 mg. KI was ingested with or 1 to 12 hours before the tracer.

In another study, thyroid uptake was measured after oral administration of ^{131}I to 62 healthy volunteers, 37 men and 25 women, aged 21 to 72 years (44); the subjects served as their own controls and KI dosages ranged from 5 to 1000 mg. KI was ingested with or 1 to 6 hours after the tracer.

Sternthal et al. (45) measured thyroid uptake in 22 euthyroid volunteers (12 men and 10 women) aged between 23 and 50 years, after oral administration of iodine 123; the subjects served as their own controls and KI dosages ranged from 10 to 100 mg. KI was ingested with the tracer.

These studies showed that thyroid uptake blockade varied as a function of the amount of KI administered (Fig. 1). A percentage of dose averted exceeding 90% was obtained among adults for a dosage on the order of 20 mg when KI was administered simultaneously with radioactive iodine exposure (43–45). Nonetheless, the minimum dosage leading to such blockade depends on individual characteristics: it is higher among subjects with an elevated thyroid uptake than among others (46).

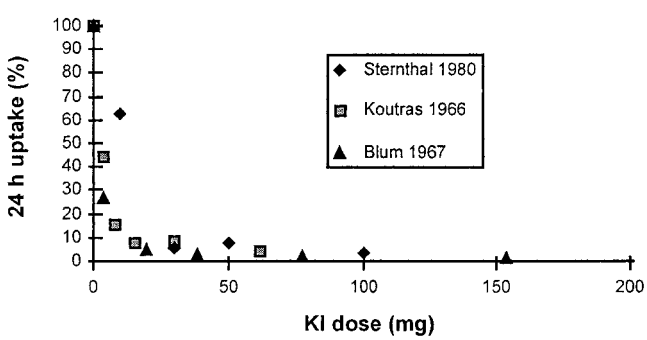

FIG. 1. Thyroid iodine 24-hour uptake as a function of potassium iodide (KI) dosage (KI ingested simultaneously with radioactive iodine). The 24-hour uptake after KI ingestion is expressed as the percentage of the 24-hour uptake without KI (43–45).

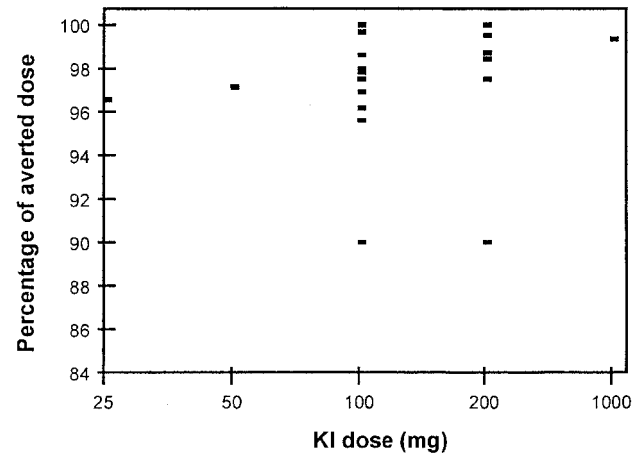

FIG. 2. Percentage of thyroid averted dose as a function of potassium iodide (KI) dosage (ingestion simultaneously with radioactive tracer). Uptake measured 24 hours after ingestion of the tracer, the percentage of dose averted is approximately equal to the percentage of thyroid uptake reduction (44).

For iodide dosages of 100 and 200 mg administered simultaneously with the tracer (Fig. 2) the dose averted to the thyroid, 24 hours after ingestion of the tracer, exceeded 95% for most subjects (44). The increase of dosages of KI above 100 to 200 mg did not appear to improve the averted dose (43).

Ramsden et al. (46) carried out repeated measures of thyroid uptake in nine subjects who had received a mixture of ^{132}I and ^{131}I after iodide doses ranging from 37 to 247 mg administered at different times (from 5.5 hours before to 4 days after the tracer). They found a percentage of averted dose of 86% when a 37 mg iodide dose was administered 24 hours before the tracer.

Modeling the data obtained in this study also showed that the uptake blockade was effective within a half hour after a KI dosage of 100 mg. This delay did not change with a higher dosage, but increased to 2.5 hours for a dosage below 25 mg (46).

Thyroid uptake blockade can also be obtained with KI doses of several milligrams. A study was carried out among 63 mentally retarded children with no thyroid anomalies, ages 1 to 11 years (20); iodide doses ranging from 0.1 to 6 mg/d were administered daily for several weeks. Iodide dosages of 3 to 4 mg led to adequate blockade of thyroid uptake only after several days to several weeks (20).

Efficacy as a function of the time of KI ingestion. Blum et al. (44) observed that 100 mg of KI blocked 98% of the thyroid dose when the KI was administered at the same instant as the tracer and 60% 3 hours after the tracer. Increasing the KI dosage did not compensate for the diminution in efficacy caused by the delay.

Pupi et al. (47) measured thyroid uptake among 29 euthyroid subjects aged 32 to 74 years (13 women and 16 men) after injection of ^{131}I; KI was administered to half the group at a dosage of 100 mg 6 hours after the tracer; a placebo was

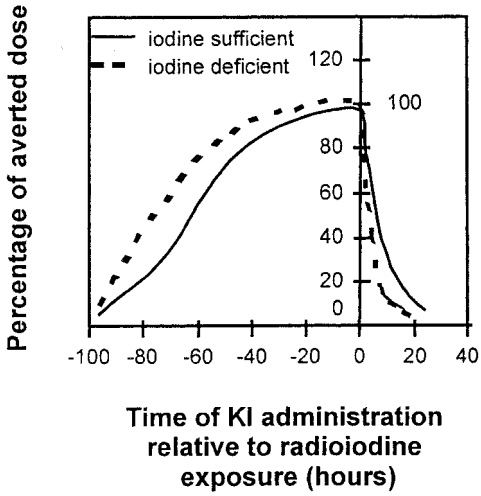

FIG. 3. Percentage of thyroid averted dose according to the delay between potassium iodide (KI) ingestion and exposure to radioactive iodine. Estimation based on a pharmacokinetic model for a single exposure in subjects with normal or deficient iodine intake. The percentage of dose averted is approximately equal to the percentage of thyroid uptake reduction (49).

administered to the other half. The cumulative content of thyroid radioactive iodine from the moment of administration to 48 hours did not differ significantly between the two groups. The thyroid dose was barely reduced, and augmenting the KI doses did not yield better results.

A simulation that was based on a pharmacokinetic model by Berman et al. (48), estimated the percentage of thyroid dose averted as a function of the time of KI administration in relation to time of exposure. For subjects with normal iodine intake the percentage of averted thyroid dose was estimated at 40% when KI was administered 8 hours after exposure (Fig. 3) (49,50). Another study yielded very similar results and showed that the optimum moment to give KI is 1 hour before exposure to the radioactive iodine (51).

Duration of the protection. Blum et al. (44) examined protection by KI 48 and 72 hours after its administration, by administering another dose of radioactive iodine. A potassium iodide dosage of 25 mg did not block uptake after 48 hours; dosages of 50 mg and 100 mg did block 66% and 78%, respectively, of the thyroid dose. At 72 hours, a KI dosage of 100 mg blocked only about 25% of the thyroid dose (Table 1, Fig. 4).

The duration of the protection was studied for an 8-day period in a sample of 5 women and 5 men free of any thyroid or renal disorder and hospitalized for gastric ulcers or myocardial infarct (52). These patients had not received any medication containing iodine. They received 200 mg of iodide (260 mg of KI) and their thyroid uptake was measured daily after an oral dose of ^{132}I. The averted dose was greater than 75% during the first 2 days of KI administration; it fell below 50% on the third day and to 15% on the fourth (Table 1, Fig. 4). Thyroid uptake returned to its baseline value after 8 days for most subjects.

Finally, Sternthal et al. (45) showed that an averted dose of more than 90% can be maintained, after an initial administration of 100 mg of iodide (130 mg of KI), by the repeated dosage for several successive days of 15 mg of iodide (about 20 mg of KI).

Cuddihy et al. (22) administered an oral dose of ^{131}I for 14 days to 4 euthyroid subjects. Two of them, 8 and 9 years old, also received 1.8 mg of iodide (about 2.3 mg of KI) each day; the other two, 22 and 23 years old, received 4.2 mg of iodide each day (about 5.5 mg of KI). The percentage of dose averted was 33%, 48%, 69%, and 62%, respectively.

Efficacy as a function of various factors. The efficacy of the thyroid uptake blockade by cutaneous application of tincture of iodine has been shown in animals and humans. In a study of 24 men between 24 and 51 years old, thyroid uptake after an oral dose of KI (130 mg) was compared to that measured among subjects who had had tincture of iodine applied to their forearms (4 mL at 2%, or 80 mg) or abdomen (8 mL at 2%, or 160 mg) (53). The mean percentage of averted dose was, respectively, 96.9%, 35.8%, and 81.7%.

TABLE 1. DURATION OF THE BLOCKADE OF THYROID IODINE UPTAKE AS A FUNCTION OF KI DOSAGE

Authors	KI ($mg\ l^-$)	Number of subjects	Averted dose (%)*					
			Day 1	Day 2	Day 3	Day 4	Day 5	Day 7
Johnson 1963[a]	200	10	88.3	75.8	41.4	14.8		
Ramsden 1967[b]	247	1	100.0	78.9			15.8	10.7
	124	1	95.6		51.1		22.2	
	37	1	86.4	36.3	15.9			
	100[c]	3		49.2 ± 10.5		22.7 ± 9.7		
Blum 1967[d]	19	1		0	−6.7			
	38	1		65.7	60.5			
	77	13		77.5	23.5			
	770	1		98.3	63.5			

[a]Uptake at 3 hours.
[b]Uptake at 30 hours.
[c]Administration of potassium iodide (KI) 1H30, 3H00 and 5H30 after the tracer, for each individual.
[d]Uptake at 24 hours, graphic assessment of averted dose; dosages are expressed in milligram of KI in the article; they were transformed to milligram of iodide (I) for purposes of comparison of the studies included in the table.
*The percentage of dose averted is approximately equal to the percentage of thyroid uptake reduction.

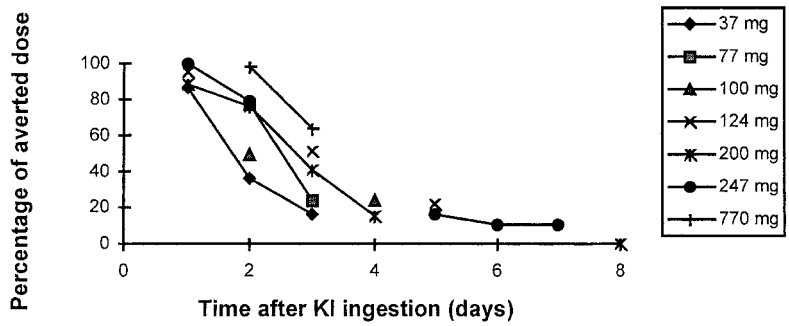

FIG. 4. Duration of thyroid blockade according to the quantity of potassium iodide (KI) ingested. Thyroid uptake measured after administration of another dose of radioactive iodine at different times after KI ingestion. The percentage of dose averted is approximately equal to the percentage of thyroid uptake reduction (44,46,52).

Animal studies provide the only data available about the efficacy of the thyroid uptake blockade in fetuses after administration of KI to their mothers. An experimental study with chimpanzees evaluated the efficacy of the thyroid blockade by KI in fetuses at between 19 and 21 weeks gestation (54). The iodide was administered orally 1 hour before the tracer. The iodide dosages ranged from 0.5 mg/kg to 5.0 mg/kg (25–250 mg of iodide for a 50-kg subject). For comparison's sake, the recommended dosage for pregnant women is 100 mg of iodide.

In all, 5 animals received these dosages. Basal thyroid uptake was also measured in 13 control animals. Without KI, the thyroid uptake of the tracer in the chimpanzee fetus was similar to that of the human fetus. All three iodide dosages resulted in percentages of averted dose greater than 90% when tracer was injected 1 hour after KI administration. However, 20 hours after KI administration, the percentage of averted dose was above 90% for only the two highest dosages, while for the lowest, it was 40%.

Dietary iodine intake levels may modify the efficacy of the thyroid uptake blockade. Zanzonico et al. (50) have estimated the protective effect of KI when administered after intake of radioactive iodine. It was significantly lower in iodine-deficient subjects compared with subjects whose iodine intake was normal.

Adverse effects of KI prophylaxis

The possible adverse effects of KI are iodine-induced hyperthyroidism, iodine-induced hypothyroidism, and nonthyroidal adverse effects. The severity of these effects depends on age, situation, and usual iodine intake.

Iodine-induced hyperthyroidism. Iodine-induced hyperthyroidism (IIH) has been observed after treatments with drugs containing iodine that were prescribed for long periods and after iodine prophylaxis programs in regions with iodine deficiency (55–58). IIH represents 6% of all diagnosed cases of thyrotoxicosis (59), with amiodarone being the most frequent cause. Amiodarone IIH is also caused by mechanisms other than excess iodine, including direct toxicity to the thyrocyte (60). Its incidence has been reported to vary between 2% and 12% and to be higher in regions with iodine deficiency (58,60–64). Besides amiodarone, many other treatments and iodinated radiology contrast agents can cause adult IIH (53,65,66).

IIH may appear in an apparently normal thyroid in the case of sudden acute or chronic iodine overload, especially in persons with low dietary iodine intake. It occurs most frequently, however, in multinodular thyroid glands, with or without goiters, or in cases of Graves' disease or toxic multinodular goiters that had remained latent because of an iodine deficiency (58).

The cardiac consequences of IIH may be severe, particularly in the elderly or in patients with patent or latent cardiac or coronary insufficiency. For example, atrial fibrillation occurs in 15% to 20% of patients with hyperthyroidism and in fewer than 1% of euthyroid adults (67).

Iodine-induced hypothyroidism. Iodine-induced hypothyroidism occurs when the uptake does not escape from the Wolff-Chaikoff effect. Among adults, this occurs most often when there are preexisting thyroid abnormalities: autoimmune thyroiditis (68), postpartum thyroiditis (69), radioiodine treatment for thyrotoxicosis, subacute thyroiditis.

Iodine-induced hypothyroidism is very frequent in newborns, especially in preterm babies, among whom an acute mild iodine overload (only 2 to 6 times the normal iodine intake) can result in hypothyroidism (70,71). The sensitivity of newborns to this effect is explained by their low thyroid iodine levels (72) and by the immaturity of their iodine uptake regulation system. Iodine-induced hypothyroidism can occur after an iodine overload in the mother either before delivery or during breastfeeding. Cases of severe neonatal hypothyroidism and sometimes of goiters have been observed after the cutaneous application of iodine antiseptics at delivery (35,54,70,71,73).

Undiagnosed iodine-induced hypothyroidism during the neonatal period, even if transient, may impair the baby's long-term neurological and mental development (71). Conversely, once diagnosed, hypothyroidism is easily treated by hormonal therapy.

The possibility of fetal hypothyroidism after maternal iodine overload cannot be excluded. Its detection is difficult: a goiter might be seen during ultrasonography (74). Treatment of the mother is necessary to correct the disorder (75,76).

Nonthyroidal adverse effects. Allergic and anaphylactic responses to iodine have been described by several authors (7,77). They may include fever, swelling of the face and body,

shortness of breath, and various rashes (called iododermas). Such consequences are exceptional, and the role of iodine in these symptoms has not been clearly demonstrated.

Stable iodide prophylaxis in Poland after Chernobyl accident. Three days after the Chernobyl accident, KI prophylaxis was implemented in Poland. The goal was to ensure thyroid doses less than 50 mSv for children under 16 years old. The recommended KI dosage regimens were 15 mg for newborns, 50 mg for children 5 years or under, and 70 mg for all other children. KI prophylaxis was not recommended for adults except for pregnant and lactating women (78).

After the KI distribution, tests were performed at birth on a sample of 3,214 newborns whose mothers had taken the prophylactic treatment. Detectable hypothyroidism was found among only 12 of them (0.37%). These anomalies disappeared at between 16 and 20 days after birth (78).

In a retrospective study conducted between 1987 and 1990 among 34,491 subjects, including 12,641 children younger than 16, no permanent thyroid dysfunction was found among children. Two of 5,061 adults suffered bronchospasms requiring emergency medical care; both already had severe bronchopathy, and no clear relation with the iodide ingestion was demonstrated. No permanent thyroid dysfunction was found among adults, except for several relapses among patients with Graves' disease. IIH in the elderly, however, may have escaped notice (78).

Discussion

KI administration allows irradiation of the thyroid to be averted in the case of exposure to accidentally released radioactive iodine. The optimal dosage is that which results in a rapid and maximal blockade of thyroid uptake (preventive effect), while avoiding or minimizing the risks of side effects.

The efficacy of the blockade and the risks of thyroid side effects depend on individual (age, thyroid iodine content, thyroid function) and external (dietary iodine intake) factors. The benefits also depend on age: thyroid cancer risk is highest for thyroid irradiation in childhood, especially before the age of 5 years, but no excess risk of thyroid cancer has been shown in adults, even after high radioactive iodine doses (2).

Pregnant women, fetuses, and newborns

Protecting the fetus against accidental radioactive iodine contamination is essential because sensitivity to radiation-induced thyroid cancer is probably highest during this period of life. No contraindication should be taken into account (not even treated maternal hyperthyroidism). The fetal thyroid does not function before the 12th week of gestation; thus, until then, iodide prophylaxis is useless for the fetus, but it is harmless and reduces maternal thyroid irradiation.

The primary risk to the fetus of this prophylaxis is neonatal hypothyroidism; this adverse effect is more frequent and pronounced in cases of iodine deficiency and prematurity. Systematic neonatal screening for hypothyroidism is carried out in most developed countries. The World Health Organization (WHO) recommends hormonal follow-up of newborns after iodide prophylaxis in mothers after a nuclear accident, especially when the dosage administered reaches or exceeds 25 mg (79). This point should be addressed in emergency plans.

Children and adolescents

The benefits of iodine prophylaxis in the case of a nuclear accident are high in these categories, because they are at great risk of radiation-induced thyroid cancer (1). At the same time, the probability of side effects is very low, as shown in Poland after the Chernobyl accident (78). A recent WHO report has emphasized the need to consider the protection of children, adolescents, and infants as a priority in the plans (80).

Elderly adults

Thyroid disorders and the risk of KI side effects increase with age, unlike the benefits of KI, which are far less clear for the elderly than for children. WHO recently recommended KI ingestion for adults over 40 years only in the case of doses to the thyroid that threaten thyroid function (80). This contrasts with other international organizations, which do not recommend different intervention levels according to age (81,82). Risk analysis studies should be carried out to compare the risks and benefits associated with iodine prophylaxis in adults to help decide whether an age limit should be proposed or whether the KI dosage should be modified.

Prolonged exposure to radioactive iodine

In some accidents, exposure to radioactive iodine may be prolonged or may occur later than initially predicted and thus make repeated KI doses necessary (80). This question should be addressed in emergency plans. In adults, smaller dosages after the initial one would maintain a very efficient protection of the thyroid and minimize the risks of adverse effects (45). More research is needed to verify whether this strategy, which is not recommended in infants and children (80), could also be applied to this most radiosensitive population.

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