POTASSIUM IODIDE – ITS VALUE AND DESTINY

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Abstract – A number of nuclear power plant postulated accident scenarios show the overwhelming presence of radioiodines in the mix of a radioactive release. The effectual manifestations of radioiodines on an unprotected thyroid gland can be medically devastating. The importance of the thyroid gland in maintaining the harmonious functioning of the body is enormous, and the role of potassium iodide in protecting the thyroid gland from overdose of radioiodines is undeniable. The availability of iodine is of utmost importance to our health. However, its excess may have serious consequences. On the one hand, this characteristic allows successful treatment of thyroid diseases; on the other, it presents a challenge when large amounts of radioiodines are present in the environment. Recent documentation on thyroid abnormalities observed in the population of southern Belarus and northern Ukraine, following the Chernobyl accident, reveals adverse effects, ranging from functional disorders to increased incidence of thyroid carcinoma. This and other recent findings may influence our decision-making process regarding the preventive use of potassium iodide. Logistical and other difficulties will affect the timely and proper distribution to “general” population. Mechanisms, available in a nuclear power plant in reducing radiiodine release, often play an important role in quantifying the radionuclide inventory. Also, protective measure scheme for the early phase of an accident, and restrictions in food consumption in the post-emergency phase will add to the qualification of administering potassium iodide. The difference in designs between the U.S. and a large number of non-U.S. plants should be considered. Proper federal guidance should be in place for the state and local officials to formulate informed decisions in the planning stage, and implement them with least difficulties. It is suggested that the decision-making process regarding administration of potassium iodide be left with the state and local officials.

Introduction

It appears that potassium iodide has received and still is receiving enough attention and political respect so that its medical importance is seemingly getting overshadowed. The issue of thyroid protection from radioactive iodines perhaps sprouted in 1954 after the large thermonuclear BRAVO bomb test over Bikini in the South Pacific. Since then, numerous studies have been conducted in order to quantify and qualify the influence of radioactive iodines on human thyroid. None of these studies was successful in

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establishing a direct quantitative relationship between the exposure to radioiodines and the extent of short-term and longer-term damage to the thyroid for doses below 100 rads (1Gy). However, even these early studies qualitatively determined that large doses of radioiodines carried a risk of adversely affecting the human thyroid gland, especially of infants and small children. Since 1954, several other incidents took place throughout the world that reinforced the need for a serious consideration of thyroid protection from radiation exposure. As a result, steps were taken in some cases to protect the population from the hazards of radiation exposure in general; in other cases, committees and expert teams were formed to conduct further studies to confirm or reconfirm the basis for a serious consideration of specific measures against thyroid exposures that could lead to the damage of this vital organ. The outcome of these investigations should be utilized in the development of scientifically based, rational and responsible guidelines. The need for such guidelines is clear, especially in the light of the most recent radiation accidents and their consequences. These guidelines will help state and local governmental agencies to focus their thoughts and considerations on thyroid protection when planning for response to nuclear power plant emergencies.

Radiogenic Thyroid Abnormalities

Adverse effects, ranging from functional disorders to increased incidence of thyroid carcinoma, have been observed in a number of irradiated populations. High prevalence of hypothyroidism and nodules and an increased incidence of thyroid cancer have been reported in the population of Marshall Islands exposed to radioactive fallout (Table 1):

Table 1
Prevalence of Thyroid Abnormalities among Marshall Islanders 27 years after exposure to fallout

<table>
<thead>
<tr>
<th>Group and Age, 1954</th>
<th>Number of Subjects</th>
<th>Dose (Gy)</th>
<th>Percent of Subjects with Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hypothyroid</td>
</tr>
<tr>
<td>Rongelap</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 yr</td>
<td>6</td>
<td>&gt;15</td>
<td>83.3</td>
</tr>
<tr>
<td>2-9</td>
<td>16</td>
<td>8-15</td>
<td>25.0</td>
</tr>
<tr>
<td>10&amp;over</td>
<td>45</td>
<td>3.4-8</td>
<td>8.9</td>
</tr>
<tr>
<td>Alingnae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10</td>
<td>7</td>
<td>2.8-4.5</td>
<td>0</td>
</tr>
<tr>
<td>10&amp;over</td>
<td>12</td>
<td>1.4-1.9</td>
<td>8.3</td>
</tr>
<tr>
<td>Utiric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10</td>
<td>64</td>
<td>0.6-1.0</td>
<td>0</td>
</tr>
<tr>
<td>10&amp;over</td>
<td>100</td>
<td>0.3-0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10</td>
<td>229</td>
<td>-</td>
<td>0.4</td>
</tr>
<tr>
<td>10&amp;over</td>
<td>371</td>
<td>-</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Values are conservative estimates[1]

Among persons exposed to therapeutic X-rays in childhood, two cohorts have been closely followed: Israeli children treated for Tinea Capitis and Rochester, N.Y. children treated for enlarged thymus. Relative risk of thyroid carcinoma for children over 5 years of age at the time of irradiation was 8.3 (95% CI: 2.31) per 100 rads (1 Gy). Carcinoma of the thyroid was the first of solid tumors noted to occur at increased frequency in the Japanese atomic bomb survivors. Continuing studies of this and other irradiated populations suggested the following generalizations: The risk of thyroid cancer appears to be increasing as a linear or
The role of iodine in thyroid physiology and treatment of abnormalities.

The human thyroid gland is a relatively small organ, weighing on average about 27 grams. Its importance in maintaining the harmonious functioning of the body is enormous. Among the most basic biological functions ascribed to thyroid hormone are control of the rate of oxygen consumption and body temperature, and regulation of the overall rate of body metabolism. The major functions include stimulation of growth and maturation of skeletal system structures, and interactions with the sympathetic nervous system [2].

The probable functions of the thyroid and the unique role that iodine plays in its physiology were learned centuries ago. Abnormalities were recognized early, partly because the location of the gland provided visible and palpable appreciation of its enlargement (goiter). Extracts of animal thyroid gland were used in developing homeopathic medicine in India and later in other parts of the world. They helped people with sluggish behavior, excessive obesity, hair loss, and other symptoms of deficient thyroid activity. Similarly, seaweed, which contains iodine, was used in Chinese medicine to treat enlargement of the thyroid[3]. These approaches had a sound pharmacological basis and proved effective in the treatment of iodine deficiency, the condition we now call hypothyroidism.

Overactivity of the thyroid (Grave’s disease), or hyperthyroidism, is the condition of opposite character in physiological terms. Externally, it is also characterized by an enlargement of thyroid gland at the front of the neck. This condition is managed by a few methods of which the administration of small amounts of Iodine-131 in the form of sodium iodide appears to be most effective. Surgical removal of part of the thyroid gland for the purpose of reducing or diminishing its activity is no longer widely practiced. Goiter can also be caused by a tumor. Following surgical removal of the tumor and the gland, this condition has been treated with large doses of I-131 for over 50 years.

The rationale of treatment of thyroid diseases with iodine compounds has its basis in the fact that iodine actively concentrates in the thyroid. We ingest it daily, some is stored, and some excreted. When incorporated into the thyroid gland, iodine is not distributed...
homogeneously throughout the follicles. Thus, when radioiodines come into play, radiation
doses are generally not distributed uniformly. They will also depend upon the energy of
emitted particles. These phenomena present dosimetric challenges, which are far from
trivial. Availability of stable iodine is of utmost importance to our health. Its excess,
however, may have serious consequences. Adding radioactivity to this picture compounds
the problem.

Severe Nuclear Power Plant Accidents and Their Consequences

Although substantial amount of radioactivity was held inside the containment building, the
Three Mile Island nuclear power plant accident, nevertheless, once again emphasized the
fact that in addition to other protective measures, thyroid protection must receive, without
delay, a very serious consideration. This is true particularly in the case of a severe reactor
accident when, among other radionuclides, large quantities of radioactive iodines are likely
to be released into the environment. The violent disassembly of the number 4 reactor at
the Ukraine's Chernobyl station in 1986 released a battery of isotopes of cesium and
iodine. These volatile materials were propelled up to the height of 10 kilometers and
rapidly spread westward over Belarus, Ukraine, and some to the east into Russia. The
entire Northern Hemisphere received detectable levels of Chernobyl's radioactivity. Even
though some instructions were issued regarding counter-measures (i.e. interdicting
contaminated milk, issuing potassium iodide pills to block the thyroid from taking up
radioiodine, etc.), they were not carried out on the local level. Some unsuspecting mothers,
who were nursing their infants during those spring 1986 weeks, transferred carcinogenic
doses of radioiodine to their infants. A newborn is about six to ten times more sensitive to
a thyroid radiation dose than an adolescent person[1].

The initial handling of this disaster opened a series of questions. Many of these questions
involve proper planning, availability and distribution of potassium iodide to the general
population residing within, and perhaps beyond a pre-determined protective action zone,
and the issues of communication.

The combination of the large number of people exposed within a short time after the
release and the high level of exposure to radioactive fallout makes the Chernobyl accident
an unprecedented event. Thousands of residents of this region experienced and are still
experiencing radiation-related sicknesses. Of particular interest is recent documentation of
thyroid abnormalities observed in the children of southern Belarus and northern Ukraine[4].

In the first four years after the accident, the number of childhood thyroid cancer cases
occurring in Belarus was in single digits but increasing every year. The highest increase
was observed in the Gomel oblast, which had relatively high radionuclide deposition
densities, where thyroid doses were greater than 50 rads (0.5 Gy). The observed
incidence rate is about 200 times higher than that seen in England and Wales, for this
normally rare tumor in children (incidence of spontaneous thyroid cancer is 0.5 per million
children per year). According to Williams et. al.[5], the incidence of childhood cancer cases
in the northern Ukraine, although lower than that in Belarus, is 20 times higher than that in
England and Wales, and 7 times higher than in the southern Ukraine. The situation in the Russian Federation is less clear.

Post-Chernobyl cases of thyroid cancers are characterized by a short latency period, a higher proportion of tumors arising in younger children and an almost equal gender ratio[6]. The morphologic features of these tumors suggest their aggressive nature with high frequency of lymph node metastases, venous invasion, extrathyroidal spread[7]. These findings strongly support a causal association between the exposure to radioiodines during and following Chernobyl explosion, and increases in thyroid cancer and other abnormalities.

Studies of these abnormalities provide new information on latency period and on populations at high risk. This information may influence our decision-making process when it comes to the appropriateness of preventive use of potassium iodide.

As it is well known, large amounts of radioiodines are present in the radionuclide inventory during normal operation of a power reactor. The highest probability of a significant release of radioiodines perhaps is associated with a main steamline break accident (in case of a boiling water reactor) or a loss of coolant accident with cladding barrier failure and lack of containment spray (in case of a pressurized water reactor). A comparison of projected thyroid doses from radioiodines available for release in two postulated accident situations is presented in Tables 2a and 2b.

Table 2a
Pressurized Water Reactor; Loss of Coolant Accident, Cladding Barrier Failure; Time Since Shutdown is = 0; Atmospheric Stability Class = F; Wind Speed = 5 Miles per Hour; Total (Mixed) Release Rate = 10 Curies per Second (Ci/Sec); Duration of Release = 1 Hour

<table>
<thead>
<tr>
<th>Downwind Distance (Miles)</th>
<th>Committed Dose Equivalent to Adult Thyroid (mrem) (With Containment Spray)</th>
<th>Committed Dose Equivalent to Adult Thyroid (mrem) (Without Containment Spray)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>35786</td>
<td>267651</td>
</tr>
<tr>
<td>2.0</td>
<td>5833</td>
<td>43623</td>
</tr>
<tr>
<td>5.0</td>
<td>1646</td>
<td>12312</td>
</tr>
<tr>
<td>10.0</td>
<td>676</td>
<td>5958</td>
</tr>
</tbody>
</table>

Iodine to Noble Gas Ratio = 0.0389

Iodine to Noble Gas Ratio = 0.389

Note: Calculations were performed with a continuous release straight line Gaussian model; release height is assumed “ground level”
Table 2b
Boiling Water Reactor; Core Melt Scenario; Time Since Shutdown is = 0; Atmospheric Stability Class = F; Wind Speed = 5 Miles per Hour; Total (Mixed) Release Rate = 10 Curies per Second (Ci/Sec); Duration of Release = 1 Hour

<table>
<thead>
<tr>
<th>Downwind Distance (Miles)</th>
<th>Committed Dose Equivalent to Adult Thyroid (mrem) (With Reduction &amp; Filtration)</th>
<th>Committed Dose Equivalent to Adult Thyroid (mrem) (Without Reduction &amp; Filtration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>1.48</td>
<td>319955</td>
</tr>
<tr>
<td>2.0</td>
<td>0.242</td>
<td>52148</td>
</tr>
<tr>
<td>5.0</td>
<td>0.0682</td>
<td>14718</td>
</tr>
<tr>
<td>10.0</td>
<td>0.028</td>
<td>6047</td>
</tr>
</tbody>
</table>

Iodine to Noble Gas Ratio = 1.46E-06

Iodine to Noble Gas Ratio = 0.585

Note: Calculations were performed with a continuous release straight line Gaussian model; release height is assumed “ground level”

Notice the dramatic change in the “Iodine to Noble Gas Ratio” when reduction and filtration mechanisms are not available. This type of scenario has an extremely low probability of occurrence.

It is apparent from these comparisons that a variety of filtration and reduction mechanisms play important roles in quantifying the actual amounts of radioiodines released to the environment. This, in turn, will influence the dose absorbed by human thyroid. One of these mechanisms, perhaps the most crucial, is the thick reinforced concrete containment building that surrounds the reactor and associated structures. The primary purpose of this building is to contain the radionuclides available for release to the atmosphere for as long as its design allows. The core-melt accident at the Three Mile Island could have resulted in substantial release of radionuclides including radioiodines had the containment failed; but owing to the availability of the containment in tact, very little radioactive release occurred. It is quite the contrary when we look at the design of the Chernobyl plant. There was no containment to prevent release.

The scenarios of severe reactor accident, where the containment is defeated or bypassed, and where the reduction / filtration mechanisms did not contribute in the reduction of radionuclide inventory, are of utmost importance. In these cases, large amounts of radiiodines are available for release to the environment through release pathways that may be unisolatable or unidentifiable, at least for a considerable length of time. This may not be the reality in most cases; however, it is what can be categorized a “fast-breaking” event when the time between recognizing the severity of this event and implementing adequate offsite protective actions is rather short. What is important here is that, as a fast and short-term measure, the population must be protected from external exposure of whole body to gamma rays as well as from dose commitment to the thyroid gland. Early evacuation (that is, evacuation before immersion in the radioactive plume), if possible, will serve both purposes. If early evacuation is not possible, then sheltering inside structures with stoppage of outside air will be the option until the plume passes beyond the area of...
sheltering. Since it is generally assumed that 100% stoppage of outside air is impossible for the normal dwelling structures, a reduction factor is applied in order to estimate the amount of radioactivity that will penetrate the structures of these dwellings. And here arises the question of thyroid protection. If a radioprotective drug was not pre-distributed to the population in question, then, legitimately, it may be too late before help arrives for this purpose.

Protective Action Schemes in U.S. and Abroad

The Three Mile Island accident of 1979 gave birth to a very comprehensive and well formulated emergency planning guidance document which is commonly known as “NUREG-0654”[8]. Using this fundamental document, states and local government agencies and nuclear power plants throughout the U.S. developed plan and procedures to respond to emergencies at nuclear power plants. Normally, a well thought-out protective action scheme becomes an inseparable part of this plan. This scheme usually provides logical and sensible measures that will be implemented for the protection of health and safety of the population residing within a specified protective action zone. In this regard, NUREG-0654 suggests, among other things, the well-known “key-hole” concept, which is used in many plans. Generally, evacuation and sheltering are applied in the protective action schemes with varied specificities depending on the local conditions and situations. Supplement 3 to NUREG-0654 recommends early evacuation (as opposed to sheltering that was previously recommended in NUREG-0654) of nearby residents (e.g., residents within a 2-mile radius and 5 miles downwind of a reactor site) as a more appropriate protective measure in the case of a severe reactor accident. This recommendation not only provides a better guidance, but also helps the implementing authorities in focusing on protective measures for people residing further out, including possibly those beyond the initially-drawn emergency planning zone. These types of protective measures are frequently practiced in the U.S. in conjunction with drills/exercises and tabletop discussions. Protective measure schemes abroad may be considerably different from the ones described above. For example, in the ex-Soviet countries protective measures (early evacuation, sheltering etc.) were undertaken only after the verification of presence of contamination on the ground that has exceeded an intervention level. This approach is now changing through acceptance of guidance provided by the International Atomic Energy Agency (IAEA).

Potassium Iodide as a Thyroid-Blocking Agent

The role of potassium iodide (KI) in protecting the thyroid gland needs no further attestation. In many Eastern-European and the ex-Soviet countries, thyroid blocking drugs are usually pre-distributed to designated local pharmacies from where citizens will receive their “quota” during a nuclear power plant accident. In the U.S., however, with a very few exceptions, distribution of thyroid blocking drugs during a nuclear power plant accident to the general population residing within a planning zone, is either not required, or not planned, or is considered “as needed”, or is limited. The influence of potassium iodide in reducing thyroid cancer resulting from exposure to radioiodines has been established through research and some experiments, including practical applications[9,13,14]. Figure 1
shows a relationship between the time of administration and the efficacy of KI. It is suggested that in order for KI to be most effective, it should be administered prior to the exposure of the thyroid gland; however, if this is not possible, then administration of KI shortly after the exposure will still be reasonably effective. This, of course, depends on the magnitude of the exposure as well.

**Figure 1**

Percentage of Thyroid Blocking by 130 mg of KI

Administration of Potassium Iodide – The Reality

Administration of potassium iodide (KI) involves or may involve a three-step process: 1) Recognition of the condition(s) that will trigger the discussion(s) on the need for KI; this will be followed by the technical justification (e.g., projection of thyroid dose commitment, and comparison with some established guidelines for this purpose) for recommending KI; 2) Receiving approval from the competent authorities to administer KI; 3) Initiation of a pre-established formal process for the distribution/administration of KI. A technical assessment group is usually involved in step 1). In step 2), a higher-level decision-making group prepares the “formal” authorization of KI. This group is normally composed of experts from a radiation control program and a health program. Step 3) involves the execution of the “formal” decision to administer KI. In this step, state and local emergency management and radiation control workers are engaged; in some cases, a group of health program workers will quite possibly become an integral part of this execution process.

Different approaches have been debated and discussed with regard to administration of potassium iodide to the population residing within a planning zone, and perhaps beyond; some foresee difficulties in implementing a scheme that is sensible; others do not see any problems; one group believes that regardless of the degree of difficulty, potassium iodide must be provided as a protective measure to the entire population that may potentially be affected as a result of an accident at a nuclear power plant. A seemingly logical approach is to pre-distribute potassium iodide to each person or household. As it was mentioned before, in some Eastern-European and ex-Soviet countries, KI is pre-distributed to designated pharmacies; during an evacuation or sheltering, citizens are instructed to receive their doses of KI from these pharmacies. This type of scheme may work in some
social and political structures; in others, this may face difficulties. In one State in the U.S., when officials went to replenish or replace the pre-distributed KI at the expiry, it was reported that in some households the supply of KI had been consumed without any notice or advisory[source: unofficial]. In some States, administration of potassium iodide to emergency workers may be automatic as soon as a radioactive release is identified. In others, however, the authorization to administer potassium iodide to identified persons (e.g., emergency workers, institutionalized persons, etc.) follows certain guidelines based on projected dose and other criteria and conditions. So, in reality, it is quite possible not to have a uniform and unique decision-making and implementation process regarding thyroid protection.

In the U.S., the conditions involving operation and maintenance of nuclear power plants, and also the emergency preparedness program are considerably different from those abroad. Keeping this in mind, to provide a set of conditions for the U.S. plants and offsite planners regarding the administration of potassium iodide based on the consequences and conclusions made after the Chernobyl accident may not serve the purpose properly. The facts, statistics and results obtained through missions and research following accidents at different facilities over the last few decades provide an in-depth understanding of this particular situation of thyroid protection, and this should be utilized cautiously and appropriately in order to make an informed decision.

The U.S. Potassium Iodide Core Group is tasked with redrafting NUREG-1633, Assessment of the Use of Potassium Iodide (KI) As a Public Protective Action During Severe Reactor Accidents. “Based on the uncertainties in the Chernobyl data, and the availability of other data that do not support the conclusion that inhalation of I-131 causes thyroid cancer, the Core Group recommended to FDA that it base its guidance development effort on raw data from Chernobyl, Hanford, Marshall Islands, Windscale, TMI-2, SL-1, “the Utah Co-hort,” etc., to the extent that such data are available. The consensus of the Core Group was that new guidance, based on any analysis less rigorous, such as accepting without question the reports from Chernobyl, would lead to a protracted and contentious comment period on the draft guidance.”[11] The Emergency Preparedness Committee (E-6 Committee) of the Conference of Radiation Control Program Directors (CRCPD) is on record in opposition to requiring state and local agencies to make KI available to members of the general public. The Committee recommends that all states document their decision regarding making KI available to the public, regardless of the nature of that decision.[11]

For U.S. plants, the following should be considered while making a decision on whether KI will be made available to the members of the “general” public residing within a specified zone surrounding a nuclear power plant site:

1) Early evacuation of the “general” population is considered adequate and the most effective protective measure in the event of a major incident at a commercial nuclear power plant. An effective evacuation will either eliminate or reduce dose to all organs including the thyroid.
2) KI will not provide protection from exposure to other radionuclides.

3) As far as the protection of the thyroid gland is concerned, small children are primarily at risk. During the progress of an emergency, when there is no imminent threat to exceed Protective Action Guidelines (PAG) beyond the site boundary, earlier precautionary evacuation of small children will play an important role.

4) There exist significant differences in the East European/ ex-Soviet plants and the U.S. plants, emergency response plans, procedures, training, and protective measures, as well as regulations.

5) Unavoidable difficulties in distributing KI to the “general” population during adverse weather conditions should influence this process.

6) Availability of potassium iodide (KI) for emergency workers and institutionalized persons is of utmost importance.

7) Logistics associated with the stockpile and distribution of KI to the “general” population may become “unmanageable”. Distribution of KI could also inhibit orderly evacuation.

8) Clear and necessary guidance on the subject should be developed and promulgated by the appropriate federal agencies.

9) State and local governmental authorities can use their discretion in making a sensible decision on whether or not KI will be considered, and subsequently stockpiled and distributed to the “general” population.

Conclusions

The probability of a severe accident at a U.S. nuclear power plant is low, but it is not null. Factors that influence this probability are “defense-in-depth” design, strict regulations, training of operators to react to symptoms rather than trying to identify and classify an accident, and of course, intensive exercising of emergency response plan and procedures. Presently, most U.S. plants, if not all, also exercise what is called “procedures for severe accident management (SAM)”. It undoubtedly adds to the qualification of accident analysis and consequence management. Since the possibility of a severe accident exists, so does the possibility of a significant release of radioiodines to the atmosphere. The human thyroid, being extremely susceptible to radioiodines, can suffer severe adverse effects when exposed to large quantities of radioiodines. The goal of the existing off-site emergency response program is to protect the health and safety of the population that could potentially be affected. One of the measures is to protect the thyroid gland, primarily of children and young population – the groups that are the most vulnerable. It is a medically analyzed and established fact that potassium iodide can provide adequate protection for the thyroid if administered prior to or immediately after an acute exposure. While the data that is presently available may not be extensive, it can be safely assumed that it is adequate, and hence a set of rational and sensible federal guidelines on thyroid...
protection can reasonably be expected to be in place. Some federal agencies have been criticized for not acting properly and timely[12]. It is comforting to learn that a chronology of the past, present and future actions in developing / revising the guidelines is in place[10]. It is necessary that the revised guidelines be published without further delay. Federal register notice on a proposed rule for “Consideration of Potassium Iodide in Emergency Plans” was published in 1999 in an attempt to revise the present rule[15]. The state and local radiation control and health officials are responsible enough to consider what is necessary for protection of the citizens based on appropriate guidelines. Therefore, the rationale, appropriateness, justification and decision-making process and the associated details regarding the distribution of a thyroid blocking drug to the emergency workers, institutionalized persons and the “general” population should rest with the appropriate state and local governmental agencies that will unmistakably include the health officials.

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References


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