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Revisiting the Goiania Radiation Accident: a Model for Different Impacts from a Malevolent Act with Radioactive Materials

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REZUMAT

Cel mai important eveniment radiologic până în prezent a avut loc în Brazilia în urmă cu 28 de ani, ca urmare a furtului unei surse de radioterapie. Autorii descriu accidentul și subliniază nevoia de planificare și pregătire în caz de urgențe radiologice. Aceasta cuprinde recunoașterea precoce a manifestărilor expunerii la radiații de către personalul din departamentele de urgență. Într-adevăr, accidentul din Goiania deservește ca model asupra diferitelor consecințe ce pot apărea dintr-un act răuvoitor cu materiale radioactive.

Cuvinte cheie: accidentul din Goiania, expunere la radiații, acte răuvoitoare cu materiale radioactive

ABSTRACT

The most serious radiological accident up to now occurred in central Brazil, twenty-eight years ago, as the result of the violation of a radiotherapy equipment. The authors describe the accident and emphasize the need for planning and preparedness to respond to radiological emergencies. This includes knowledge for early recognition of medical manifestations of radiation exposure by medical emergency department personnel. Indeed, the Goiania accident serves as a model for the different impacts that can arise from a malevolent act with radioactive materials.

Key-words: The Goiania accident, radiation exposure, malevolent acts with radioactive materials

Introduction

On September 13, 1987, in Goiania, the capital city of State of Goiás, in central Brazil, two individuals removed the head of a radiotherapy device containing a 50.8 TBq ^{137}Cs (cesium-137) source, left behind in a derelict clinic, to the house of one of them. As the result of the violation of the source integrity and its selling to junkyards, many persons were irradiated and also incurred external and internal contamination [1].

As a consequence of radiation exposure, 20 persons were hospitalized in Goiania and Rio de Janeiro; 17 developed bone marrow depression and 8 the full picture of the acute radiation syndrome and 4 patients died. Besides, 112,800 persons were triaged in Goiania for possible radiation contamination that was disclosed in 129 individuals, although restricted to clothes and shoes in 120 of these persons.

Presently, revisiting the Goiania accident is very appropriate, as it may serve as a model for the study of possible consequences of malevolent acts using radioactive materials [2].

The identification of the accident

Radiation exposures began immediately after the source violation on September 13, 1987. Thereafter many individuals developed the prodromal manifestations of the acute radiation syndrome (ARS), the syndrome itself and variable degrees of the cutaneous radiation syndrome (CRS) [3, 4]. Although many persons looked for medical attention in Goiania, they were misdiagnosed as having pemphygus foliaceus, atopic dermatitis, insect bites, etc. The etiology of the manifestations was only made clear on September 29, 1987 [5].

The delay on the correct diagnoses caused medical aggravation of the injuries in virtue of lack of appropriate treatment and additional doses and incorporations of cesium, an additional number of exposed people and exacerbation of other impacts: environmental, economical and psychological.

An evident lesson from the Goiania accident is that health personnel must be prepared to identify medical manifestations of accidental radiation exposures. That especially applies to medical emergency department personnel [6].

The structure of the medical response

The medical response to the accident was established on a three-level basis: at an out-patient unit in Goiania; at a specially prepared ward in the

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Goiania General Hospital (HGG) and at the Marcílio Dias Navy Hospital (HNMD), in Rio de Janeiro, for the most severe cases.

This structure was based on an existing system to respond to radiation emergencies at the Angra dos Reis Nuclear Power Plant (State of Rio de Janeiro, Brazil) and was quite successful to deal with the acute health problems caused by the accident.

The Goiania accident demonstrated that the medical impacts of radiological accidents can be even more severe than those from nuclear ones; that there must be planning and preparedness to medically respond to radiological emergencies too and that information and training, both in local hospitals and tertiary centres must be "socialized", that is, it cannot be restricted to nuclear medicine doctors and radiotherapists. Indeed, emergency medical department personnel, surgeons, internists, haematologist and others must be well aware of the medical manifestations of undue radiation exposure.

Other considerations and lessons

Doses [7] were estimated taking into account exposure histories, prodromal manifestations and clinical and haematological evolutions. The uncertainties about the information delivered by the victims, the protracted and non-homogeneous nature of the exposures and the association of conditions, all made clinical estimations of doses very difficult. Chromosome analysis was also used for dose estimation, but the same drawbacks are pertinent for this method too. Cesium burdens were mainly determined by urine and feces bioassays.

Cesium decorporations were significantly improved by Prussian Blue and were followed up by periodical bioassays and lately also by a specially designed whole-body counter.
The Goiania accident was the first opportunity for the use of GM-CSF in patients with accidental radiation-induced bone marrow failure. This experience opened way for the indication of this drug, on a much more rational basis, in other radiation accidents, as in El Salvador (1989), Soreq, Israel (1990) and Tokai-mura, Japan (1999).

The Goiania radiation accident has been considered the most serious one in the occidental hemisphere and resulted in four fatalities, serious injuries (one patient had his left forearm amputated) in many people and environmental contamination in the central part of the city. Besides medical consequences, psychological, social and economic impacts were very significant. Indeed, the Goiania accident can be categorized as a disaster, in accordance to the many different literature definitions for such a condition. The city clean-up resulted in 3,500 m^3 of waste initially accommodated in a provisory disposal site. Later on, a definitive waste disposal site was constructed in Abadia de Goiás, about 30 km far from the city of Goiania. In this place, the Brazilian Nuclear Energy Commission (CNEN) built its Regional Centre of Nuclear Sciences. Yet, as a result of contamination, seven houses had to be demolished.

Discrimination against victims and their relatives, friends and neighbours was intense. Vehicles with the State of Goiás plates were not allowed to enter in other states. Prejudice against Goiás citizens in airports, interstate bus stations was also observed. As an example of this, the Goiás representation was not allowed to be present in a traditional beneficent Catholic fair in Rio in December 1987.
Police force had to be used to permit the burials of the corpses of the fatal victims in Goiania, as many locals were afraid of the contamination of the cemetery.

Following a boycott of Goiás products, the State Gross Internal Product dropped about 30% within four months after the accident.

The present

The medical, psychological and social follow-up and assistance of the victims of the accident has been delivered by a branch of the State of Goiás Health Agency.

For the purpose of follow-up, persons involved in the accident were divided in groups (**Table *1***).

One group I patient died in 1994 (cytogenetic estimated whole-body dose of 5.3 Gy) of alcoholic cirrhosis (an adenocarcinoma of the lower esophagus and a carcinoma of the prostate were found in autopsy). Also in group I individuals, a heavy smoker died of a bladder cancer, and another of a tonsil cancer. In both cases, no association with radiation exposure is possible to be established. A group I patient had a myelodysplasic syndrome (MDS) diagnosed, but the long latency period after the accident makes radiation an unlikely etiology.

Besides recurrences of local radiation injuries in three patients, the most relevant problems observed in all groups are psychosocial ones, like psychosomatic manifestations, drug abuse and fear of death by radiation related diseases, especially cancer.

A significant number of litigations against CNEN have occurred and many persons were admitted for medical assistance and follow-up in virtue of legal determinations, the reason for the large number of persons in group III.

Demands against CNEN refer almost exclusively to litigations by military people and other individuals that worked in the clean-up of the city and that ascribe usual medical conditions they present, like diabetes and hypertension, to equivocal radiation exposure. This problem has

been very difficult to handle and should be considered from the very beginning in any significant radiation accident.

Group	Criteria	Persons
I	Acute Radiation Syndrome and or Cutaneous Radiation Syndrome and or cytogenetics dose ≥0,2 Gy and or ^{137}Cs burden ≥1/2Annual Limit on Intake - ALI	58 42 children of the followed-up individuals
II	Cytogenetics dose ≤0,2 Gy and or ^{137}Cs burden ≤1/2ALI	47 38 children of the followed-up individuals
III	Not included in the above criteria, but a "social" victim (e.g.: the person lost his/her house) or admitted by a legal determination	890

Table 1 - Follow - up groups

Fig1. Allopecia

Fig2. Radionecrosis of the right thigh

Fig3. Amputation of right forearm

Conclusions

The Goiania accident was characterized by protracted exposures [8] to ionizing radiation. The violation of the cesium source happened on September 13, 1987 and the accident's nature was only disclosed sixteen days later. This fact was mainly caused because local health personnel were not able to identify the clinical manifestations of the victims as radiation-induced ones. A planted radiation source (Radiological Exposure Device – RED) could also determine protracted exposures of persons. One lesson from Goiania is that health personnel must be aware of the clinical manifestations of whole body and local radiation exposures (acute radiation and cutaneous radiation syndromes). The suspicion by health personnel that people is being exposed to ionizing radiation may be an important clue to identifying lost or planted sources. On the other hand, if clinical manifestations of radiation exposure are not timely recognized, it is evident that the consequences of the episode will be made much worse (as in Goiania).

Another aspect refers to both internal and external contamination. Besides conventional injuries, the detonation of a Radiological Dispersal Device (RDD) could also cause both external irradiation and also contamination (as in Goiania). It is possible that the preferable radiation source in a "dirty bomb" would be a ^{137}Cs one, because of its chemical properties. In this respect, authorities in charge to responding to a radiation attack must consider aspects like hospitals preparedness to cope with patients both with conventional trauma but also with radiation contamination; the supply of specific drugs like Prussian Blue; medical protocols for triage and treatment of victims with radiation injuries; mass communication and the handling of the psychological impact and the immediate and

long-term consequences of a radiation emergency.

Last but not least, a serious problem observed in the Goiania accident was that emergency physicians and other health personnel did not recognize the manifestations of the patients there were looking for as radiation-induced ones. Misdiagnoses as pemphigus, food intoxication, insect bites, etc. were made instead. This fact was an important component to aggravate all the consequences of the accident [9].

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