Radiation Protection / Medical Aspects of the Goiania Accident Individual Monitoring

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In September 1987, the rotating assembly of the shielding head of a Teletherapy unit was removed and the capsule containing 50.9 TBq of ^{137}Cs was dismantled resulting in the widespread contamination of the central Goiania city. This accident resulted in the external and internal exposure of several people, of both genders and of ages ranging from newborn to 73 years old. Sixteen days elapsed between the breaching of the source and the discovery of the accident During this time, children and adults suffered whole body irradiation and became internally contaminated from eating with contamination hands and from contaminated utensils.

People who had handled the source, who lived in houses adjacents to the contaminated sites, or who had some type of contact with the victims were referred to the stadium for monitoring. The first screening contamination was done using a Geiger-Muller detector About 110,000 persons were monitored and 249 had internal and/or external contamination Urine samples were collected to select the people internally contaminated and to evaluate the ^{137}Cs intake and the radiation dose Blood samples were also collected for dose assessment through cytogenetic technique. A total of 20 persons were hospitalized The most seriously injured patients, 14 individuals, were transferred to a hospital in Rio de Janeiro Patients requiring less intensive care, 6 individuals, were admitted to the Goiânia General Hospital. People presenting only slight internal and external contamination, and individuals who had their homes sealed off, were referred to the Institute for Protection of Minors.

During the first two months urine and feces analysis was used to evaluate the ^{137}Cs internal contamination and the efficacy of PB on ^{137}Cs decorporation Goiania is located far from any radiation protection center with the capability to perform in vivo measurements and in vitro monitoring was considered the best technique since most of the individuals had external contamination which would interfere with the in vivo monitoring results

A field whole-body counter was installed in the Goiânia General Hospital, in November 1987. The first in vivo measurement system had to be appropriate to measure high level of ^{137}Cs activities. The NaI(Tl) detector was positioned in a distance of 2.23-m from the floor. The minimum detectable activity was equal to 9 kBq for 2 minutes counting time ($p < 0.05$). Eight months after the intake, January 1989, the distance of the detector from the floor was reduced to 1 36-m The minimum detectable activity decreased to 1.75 kBq for 2 minutes counting time ($p < 0\ 05$) In order to maintain the follow up of the internal contaminated individuals and, also to implement the occupational monitoring of workers from the radioactive waste repository, at the end of July 1991 a multiple geometry system for whole body measurements was installed in Goiania In this case, the detector and shielding could be moved in vertical and horizontal directions allowing to measure either children or adults and also measure high and low activities The minimum detectable activity was equal to 218 Bq for adult geometry and 31 Bq for baby geometry for 30 minutes counting time, Oliveira et al. (1991) and Melo et al, (1998a). During a short period of time, both monitoring methods were simultaneously applied to many individuals The comparison of the results obtained from both methods shows that the total ^{137}Cs activity (Bq) excreted in a time period is similar to the difference between two consecutive whole-body measurements in the same time period. The same was observed when the biological half-times estimated using excreta and whole body measurements data were compared. These results show that both techniques are compatible, (Melo et al., 1994).

An improved biokinetic model for ^{137}Cs in humans was developed based on an analysis of the bioassay data obtained from individuals involved in this accident In addition to the data on ^{137}Cs retention from these individuals, data from a study on the metabolism of ^{137}Cs in immature, adult and aged Beagle dogs and data from the literature were used in the formulation of the ^{137}Cs biokinetic model. Mathematically, the retention of cesium is described by three exponential terms. The first term represents mainly the elimination of ^{137}Cs filtered by the kidneys within a few hours of its entry into blood. The second term reflects the progressive loss in urine and feces of ^{137}Cs retained in tissues Skeletal muscle dominates the second retention term for two reasons the predominance of active transport in the cells of that tissue and the fact that muscle is a slowly exchanging tissue The third exponential term may reflect the retention in the subcellular fraction in the skeletal muscle tissue The retention fraction was found to be equal to 0.001 and the biological half-time equal to 500 days (Melo et al , 1997)

Among the individuals there were two pregnant women. One of them had the ^{137}Cs intake in the fourth month of pregnancy The ^{137}Cs concentration of the mother's body, of the infant's body and of the placenta was very similar. It indicates an easy and homogeneous ^{137}Cs transport from mother to fetus and also a lack of any placental barrier for cesium In this case the cesium was available in the blood to be transferred to the fetus The ^{137}Cs transfer factor from mother to fetus was equal to 1. The second woman became pregnant 3

years and 8 months after ^{137}Cs intake The cesium concentration of the mother's body was 13 times higher than infant It was not found any measurable ^{137}Cs activity in the placenta The ^{137}Cs transfer factor from mother to fetus was equal to 0.08 (Melo et al., 1998b)

Prussian blue (PB, Radiogardase) has been successfully used as a decorporation agent to accelerate the clearance of cesium deposited in the body. PB is administered orally and acts in the lumen of the intestine to decrease the enterohepatic circulation and to increase the amount of cesium excreted in feces. Forty six individuals internally contaminated with ^{137}Cs in the Goiania radiological accident were treated with PB in dosages varying from 1 to 3 g d^{-1} for children and from 3 to 10 g d^{-1} for adolescents and adults. PB was administered orally 2, 3 or 6 times per day, depending on the total dosage, with a minimum of 2 h between consecutive administrations. As two weeks had elapsed when the accident was discovered, PB treatments started at least 10 d after the cesium intake For people who were contaminated in the Goiania accident and received PB treatment, the estimated biological half-times refer to the second term of the retention equation. These human data were complemented with an exoeriment with beagle dogs, Melo et al, 1996. The effectiveness of PB was found to be dependent on the time treatment is started When PB treatment starts before or immediately after Cs intake its effectiveness is increased since it acts by doubling the short term elimination fraction (demonstrated in dogs) as well as by decreasing the long term half-time to constant species-specific values (about 26 d in human beings and 13 d in dogs). If PB administration is delayed it can not influence the fast clearance phase of Cs. Probably there is a minimum dosage (g kg^{-1} of body weight) of PB that should be given to patients to make it effective for enhancing clearance of Cs from the body, Melo et al., (1998c)

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