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Radiological Accident in Salvador, Bahia

- Physical and Medical Aspects -

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Between 25 September and 9 November 1997, a radiological accident occurred, involving three workers of a Brazilian mineral processed industry, during the maintenance of an X-ray diffraction equipment

The accident reconstitution was done in four steps interviews with involved persons; dosimetric evaluation with radiographic films, ionizing chamber and thermoluminescence dosimeters, cytogenetic dosimetry, and taking the X-ray diffraction equipment apart.

The results of investigation showed that the radiological accident happened during the calibration of the X-ray diffraction equipment and that the victims had their hands exposed to high level of radiation between 5.6 and 20 Gy. These radiation doses began an erythema process with progressive injuries

It was concluded that the causes of the radiological accidents were due to lack of maintenance of the main part of the equipment, where the X-ray is liberated and, the non observance of maintenance, calibration and radiation protection procedures

Some recommendation about radiation protection and safe use of the X-ray diffraction equipment are also shown in this paper.

Medical aspects

The accident occurred at an industry in Camaçari, State of Bahia, Brazil, that processes ilmenite ore for the production of titanium dioxide - TiO_2 which pellets are analyzed through X-ray diffraction. The used equipment has as specifications 36 kV, 50 mA and 1800 kW. The dosimetric reconstructive efforts and results were demonstrated by Dr. Carlos Austerlitz, so that we are limited to the medical aspects of the accident

Cases descriptions

Patient 1

IPM, male, 30 year-old. On September 25 1995, he began maintenance work at the difractometer. On day 4, three hours after beginning working, he observed erythema and experienced a burning sensation on the dorsum of the left hand

There was initial mild pain and progressive extensive edema and bullae formation with exsudation and hyperpigmentation on the dorsum of both hands in the next days.

Evolution consisted of exsudative lesions on the patient's left hand, the opening of flictenae and of a favorable evolution, clearly observed on day 157 after the initial exposure Hypopgimentaion on the dorsum of both hands is the only sequel. A skin graft was inserted for a shallow but persistent ulcer.

Patient 2

GSL, male, 23 year-old, observed IML's work during September 27 and 29, 1995. Between days 7 and 9, he noticed erythema on the tip of the 2nd finger of the right hand, with flictena formation about days 10 and 12. On day 13, a flictena with a black basis was evident on the same region On day 14, erythema had extended to the latero-internal region of the same finger Evolution was very favorable too, the only "reliquat" being a very discrete atrophy on the tip of the affected finger

Patient 3

CMA, male, 53 year-old, on November 9, 1995 (day 0), aligned the screws of the equipment's collimator for a new dosimetric test In 4 or 5 different occasions he came with his hands about 20 cm close to a place of a high dose rate, as later identified Four to 5 hours later, he complained of a burning sensation on the right hand dorsum.

On day 1 erythema appeared on his right hand and on day 21 the same burning sensation was referred on the 4th and 5th fingers of the left hand with small flictenae development. Evolution was one of bullae on the right hand at day 25, with complete healing by day 55.

Identification of the Accident

Patient 1 looked for 3 or 4 different doctors, but the lesions were only suspected to have a radiation cause at The Center for the Study of the Worker's Health, in Salvador Then CNEN was notified. I was sent on October 13, 1995 to Camaçari with Dr. Austerlitz.

The occupational histories, the lack of exposure to other agents, the latency period of the manifestations, preceded by an erythema and the clinical aspects of the lesions, made the radiological etiology very likely, although the initial efforts to identify radiation exposure were not successful.

IPM's blood chromosome analysis[1] in the Radioprotection Institute of CNEN - IRD - in Rio de Janeiro had not the purpose to establishing a cytogenetic dosimetry, but one of the cells had a tricentric and another a dicentric and 3 fragments in excess, finding that were compatible with a high very localized radiation exposure

Doses evaluations

In accordance to reconstitution with hand simulators, patients could have exposed on the dorsum of the right hand from 0.20 to 4.44 Gh/h. On the left, from 0 19 to 2.15 Gh/h.

IPM clinical doses take into account that the received a non-homogeneous and fractionated exposure They probably ranged from 5-8 Gy on erythema areas, to higher doses, where flictenae and ulceration developed (12 to 20 Gy or more). Probably, the highest dose was to the metacarpo-falangeal region of the 2nd left finger, where a shallow ulceration demanded a graft.

IPM manipulated the primary beam alignment screw during the four working days for "more than 170 times"(number of times he triggered the X-ray emission), making impossible to calculate his doses by considering the dosimetric findings, the position of his hands while working and the length of the exposures

GSL physical doses estimations were possible, as he clearly informed his working conditions They were about 21 8 Gy on the tip affected finger and about 1.8 Gy on the other regions of the same finger and come close with the clinically estimated doses (about 25 Gy on the extremity of the finger)

In fact, in this patient erythema was earlier, appearing in the 1st week post-exposure, followed by flictena formation and shallow and punctual tissue necrosis

Dose estimation to CMA was also possible considering the history of his exposure Maximum dose to the dorsum of his right hand was calculated to be about 15 Gy and this correlates well with the clinical manifestations

Conclusions

The delay physicians had to identify the origin of the exhibited lesions is a common fact of this accident with others and highlights the need of informing occupational and health personnel in general on the clinical manifestations of radiation injuries.

In the industry there was a false sense of security, so maintenance personnel did not use personal dosimeters. For years, blocking the interlocks during calibration was a "normal" routine, that did not cause before a similar accident only because the difractometer's back window had not yet been damaged

Overexposures were caused by poor maintenance of the device, but lack of training and information are important facts too

Besides, this accident in an apparent "inoffensive" difractometer confirms that radiation accidents can occur wherever ionizing radiation is used.

Finally, it is worth mentioning that albeit the apparent seriousness of the lesions, evolution were favorable, demanding conservative treatments. It is important to consider the low energy of the X-ray that spared the deeper layers of the tegument of high doses