HEALTH PHYSICS EVALUATION OF AN ACUTE OVEREXPOSURE TO A RADIOGRAPHY SOURCE

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Industrial radiography in South Africa has grown since 1948 to the present use of, inter alia, 130 iridium-192 sources (up to 200 Ci) by 29 firms. Although it remains the main cause of overexposure (1) in the use of radioisotopes, only two persons have suffered clinically observable injury before this incident in 1977. The one person who was here acutely overexposed, was followed-up by physical dosimetry, chromosome studies and medical surveillance.

1. THE INCIDENT

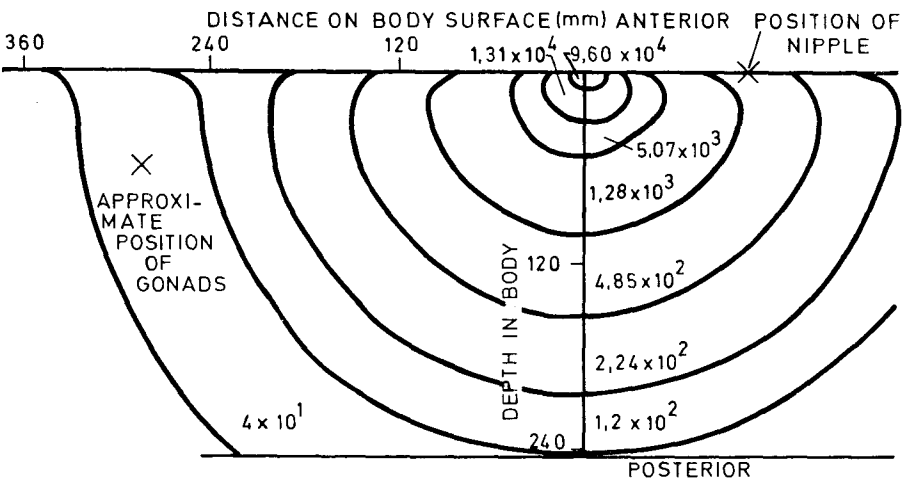
During radiography at a construction site a 6,7 Ci ^{192}Ir-source fell out of its container on Saturday morning, 8 January 1977. This was not noticed by the radiographer because of a faulty monitor, and he subsequently left the construction site. About 3 h later a construction supervisor, A, picked up the bright metallic object which he assumed to be a component of a mobile crane, and placed it in the left breast pocket of his shirt. Subsequently, he travelled home in a small bus with 6 other occupants who alighted at various points along the route, with A reaching his home after 40 min when he sat down to watch a television program. About 40 min later he became nauseous and vomited, and removed his shirt which was placed in a cupboard, and went to bed. The next morning he removed some money and the source from the shirt and placed it in the drawer of his bedside table. The family spent the rest of the day away from their house, retiring to bed at 20h00 with A immediately next to the bedside table and his 6-year old son sleeping between him and his wife. On Monday he left for work at 06h00 while his wife and son remained at home.

The loss of the source was discovered at 11h30 on the Monday when a search was instituted by the firm with the aid of radiation monitors. As the search proved fruitless, a replica of the source capsule was shown to the workers on site with subsequent identification and recovery of the source from A's bedside table at 15h45. In the meantime, the loss of the source was reported to the Atomic Energy Board, the South African regulatory body, at 13h45.

2. HEALTH PHYSICS

Due to the magnitude of the accident, A was admitted to hospital for observation and his family as well as his colleagues were immediately placed under medical supervision. Subsequent dosimetric calculations indicated that in addition to his family, only three colleagues (X, Y and Z) were to remain under medical observation, but that at no stage was any member of the public exposed to a level which warranted surveillance.

Although statements were obtained from A, his superiors, colleagues and the industrial radiographer, it was extremely difficult to reconstruct the accident in detail. It could, however, be derived with a fair amount of accuracy that the source remained in his pocket for 2 h 40 min, although its position in relation to his body (it was a loose-hanging shirt) could not be determined accurately. For dosimetric purposes it was considered that 33 % of the time was spent in the sitting position with the source approx. 60 mm from his body, whereas the source capsule was considered to be in contact with his skin in the standing and prone positions. Isodose curves were calculated using the shielding program PELSHIE (2), assuming a point source irradiating the body, considered as a slab of water - as presented in the following figure.



ISODOSE CURVES IN RAD (PATIENT A : 1,83 m 85 kg)

Drastic assumptions had to be made for the calculation of the whole-body dose, estimated as 133 rad.

Although the eventual biological effects were underestimated during the initial clinical examinations, the physical dosimetry led to A being kept under close medical observation as well as the decision to request chromosome dosimetry.

3. CHROMOSOME DOSIMETRY

On 31 January 10 ml blood samples from 6 people were placed in sterile heparinised specimen tubes and despatched by air to the National Radiological Protection Board in England. Here lymphocyte cultures were set up following a routine technique, incubated for 48 h and metaphase preparations examined for the presence of unstable chromosome aberrations (3).

The aberrations found and the resulting dose estimated together with their 95 % confidence limits based on scoring statistics, are

presented in the following table.

	No. cells	Dicentrics	Centric rings	Acentrics	Dose (rads)	95 % Confidence limits Lower	Upper
A	1 000	86	2	60	116	98	133
Wife	500	2	-	10	17	2	40
Child	500	1	-	3	10	2	34
X	500	-	-	1	-	-	26
Y	500	-	-	3	-	-	26
Z	500	-	-	5	-	-	26

The estimates of dose were available on 4 February, 5 days after the blood samples were taken, and were made by reference to an in vitro calibration curve produced with cobalt-60 gamme rays (4).

The cytogenetic method provided estimates of whole-body dose in agreement with the uncertain calculations, but did not permit quantitative estimates to be made of the absorbed dose to specific parts of the body. However, in the case of A, the distribution of the aberrations was not Poisson, which provided a firm indication that his exposure was not uniform.

4. MEDICAL OBSERVATIONS

The dosimetric evidence was confirmed by subsequent medical examinations and only A showed any clinical evidence of radiation injury.

The patient developed a slight nausea and loss of appetite within hours after exposure, that lasted only for about 24 h. ECG studies done at 1 week, 6 weeks and 18 months after exposure did not reveal any abnormalities. His blood pressure remained constant. Examinations of his urine done at weekly intervals were normal. The patient's wife gave birth to a full-term normal baby about a year after the incident.

Mentally the patient became depressed, being unable to do his normal work as a result of his injured left hand. No shortness of breath or infection occurred during this follow-up period. Chest X-rays done at monthly intervals, were within normal limits and no fibrotic changes were observed.

4.1 Laboratory Studies

Full blood counts as well as the sedimentation rate were determined, first at two-day intervals and then at weekly intervals. The haemoglobin, white-cell count, as well as the differential white-cell count remained within normal limits. The only abnormality was a change in the sedimentation rate which was normal on day three and rose to 50 (NV 0-9 Wintrobe) on day nine. Twenty-four days after exposure it was back to normal.

Liver and kidney function remained within normal limits.

4.2 Local Reactions

The thumb and index finger of the right hand started with an

erythema reaction on day 18, that developed into a wet dermatitis on day 20, but eventually healed completely within the next 10 days. Clinical estimation of the radiation dose was difficult but judging by the reactions (5) about 1 000 rad was received.

The thumb and index finger as well as the middle finger of the left hand started with an erythema on day four, which developed into a wet dermatitis as well as blister formation after ten days. The hand was very painful and on day 20 the full skin thickness was shed. The healing of the fingers was very slow and incomplete and after three months were covered with atrophic skin that tended to break down repeatedly after minor trauma. This required amputation of the index and middle finger after 24 months. The estimated dose equivalent is over 5 000 rad.

Two days after exposure erythema developed over about 180 cm^2 of the anterior chest wall. This progressed to wet desquamation on day six, followed by necrosis in the centre. Healing started from the periphery and two months after exposure there was a 60 cm^2 (8 cm x 15 cm triangle) necrotic area surrounded by slightly atrophic depigmented skin, which was very painful. The necrotic area remained unchanged and excision and pedicle skin graft was required 18 months after the incident. By means of the Strandqvist method (6) the central necrotic part was estimated to have received between 5 000 and 10 000 rad. The adjoining area received between 1 000 and 2 250 rad. This is in remarkable agreement with the physical calculations, especially as the source was not stationary.

5. CONCLUSION

This accident has pointed out the inherent weakness of pneumatic radiographic equipment and, consequently, the further use of such equipment in South Africa has been prohibited. A system of log-sheets has also been introduced whereby the compulsory monitoring of a source inside its container must be recorded before storage.

The radiography firm as well as two of the employees have been criminally prosecuted and convicted.

The direct physical evaluation of radiation exposure proved its value in keeping the severely overexposed subject under medical surveillance.

6. ACKNOWLEDGEMENT

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7. REFERENCES

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