ABSORBED DOSE TO TECHNICIANS WORKING AT ACCELERATORS FOR RADIATION THERAPY

A. Almén, L. Ahlgren and S. Mattsson
Department of Radiation Physics Malmö
University of Lund
Malmö Allmänna Sjukhus
S-214 01 MALMÖ

ABSTRACT

Absorbed dose to the trunk and the hands of technicians working at high-energy accelerators for radiotherapy have been measured for seven accelerator in different hospitals. Induced radioactivity and leakage radiation have been studied. The annual absorbed dose to the trunk was estimated to 2.0 mGy. Induced radioactivity contributed with 1/3 of the total absorbed dose. For one accelerator the variation of absorbed dose rate after an irradiation inside the treatment room was followed. Radionuclides with rather long halflives e.g. ^{187}W were identified.

INTRODUCTION

External radiotherapy is mainly carried out with photon or electron beams from electron accelerators. The technicians operating these accelerators will be irradiated from photons penetrating the radiation shield in the accelerator head and the walls of the treatment room. Photons scattered in the patient and in the treatment room before penetration of the walls will also contribute. If the photon energy exceeds 8-10 MeV the technicians when inside the treatment room will be irradiated by induced radioactivity produced by photonuclear reactions. The highest induced activity is expected in the parts of the accelerator exposed by the highest photon fluence. Depending on the photon energy and irradiated material a number of radionuclides will be produced with different halflives. Neutrons will also be produced.

The aim of this study was to estimate the absorbed dose to technicians working at accelerators producing high-energy photons due to induced radioactivity and leakage radiation.

MATERIALS AND METHODS

Absorbed dose to 24 technicians working at seven high energy accelerators in six different hospitals in Sweden was measured. The accelerators used accelerating potentials above 10 MV producing photon and electron beams of different energies.

Five TL-dosimeters (LiF, 3.2*3.2*0.9 mm^3) were carried on the trunk and five on a wrist bracelet. The dosimeters on the trunk were covered with 5 mm buildup material, the dosimeters on the wrist had no additional buildup accept a thin plastic cover. The dosimeters were calibrated in a ^{60}Co-field. During the measuring period of ten working days the background radiation and the radiation at the control console was measured with TL-dosimeters. A pressurized ionisation chamber (Victoreen 450P) was also used to measure the absorbed dose rate due to leakage and scattered radiation at the control console when high-energy photons were used. The leakage radiation inside the treatment room was measured with a ionizing chamber one meter from the isocenter perpendicular to the central beam axis. For the measurements a 50 mm buildup cap was used.

The time variation of the absorbed dose rate due to induced activity after a treatment with high-energy photons in one treatment room was measured with a NaI(Tl)-detector placed at the isocenter and at 1.3 m above the floor at a location beside the treatment couch. The measurement was carried out for one accelerator and started 0.5 min after the irradiation and went on for 48 h. The signal from the NaI(Tl)-detector was compared with readings from a plastic scintillation detector calibrated for absorbed dose measurements. The curves over count-rate versus time were analyzed and separated into several exponential functions.

RESULTS AND DISCUSSION

Absorbed dose rate outside the treatment room due to leakage radiation during a treatment with high-energy photons varied considerably between the accelerators (Table 1). Table 1 also shows the leakage radiation through the accelerator head in the treatment room. The leakage radiation is given per absorbed dose unit given to the patient. Inside the treatment room the average absorbed dose measured divided by absorbed dose maximum in water at isocenter is given in table 1.

Table 1. Leakage radiation inside the treatment room and at the control console, when irradiating with high-energy photons.

Designation	Manufacturer	Leak. rad. inside/ mGy/Gy	Leak. rad. control console/µGy/h
Linac 1	Clinac 1800 Varian	0.134	4.4
Linac 2	SL 75/20 Philips	0.135	0.4
Linac 3	SL 75/20 Philips	0.347	1.0
Linac 4	Dynaray LA20 Brown Boveri	0.435	1.2
Linac 5	SL 25/20 Philips	0.459	0.2
Microtron 1	MM22 Scanditronix	0.513	1.4
Microtron 2 Race trac	MM50 Scanditronix	0.462	2.5

The annual dose was calculated by extrapolating the measured dose to one year assuming a workload of 45 week in a year. The natural background was subtracted from the TL-readings. The absorbed dose at the control console was calculated and was subtracted from the total absorbed dose. Estimation of the contribution from induced radioactivity to the total absorbed dose was then obtained. The average absorbed dose to the trunk was estimated to 2.0 mGy per year. In figure 1 the mean absorbed dose to the technicians at each accelerator are given.

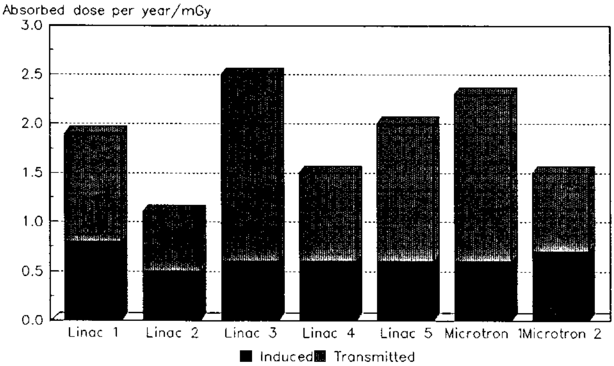

Figure 1 The measured absorbed dose to the trunk extrapolated to one year.

In the same way the absorbed dose to the hand was calculated for the different accelerators to 2.1 mGy. The dose to the hands varies from 0.7 to 3.3 mGy.

A similar investigation (LaRiviere P, 1985) has given comparable absorbed doses. His registred dose outside the treatment room is however lower. This could be due to different measuring techniques or due to that the control console is very distant from the accelerator.

At the control console the average dose rate was measured to 1.6 µGy/h. The average leakage dose rate inside the the room was 0.36 mGy/Gy.

A number of radionuclides was identified by examining the halflives. The identified nuclides were also compared with gamma spectroscopy measurments (Ahlgren et al, 1988). An example of the absorbed dose rate curve is given in figure 2.

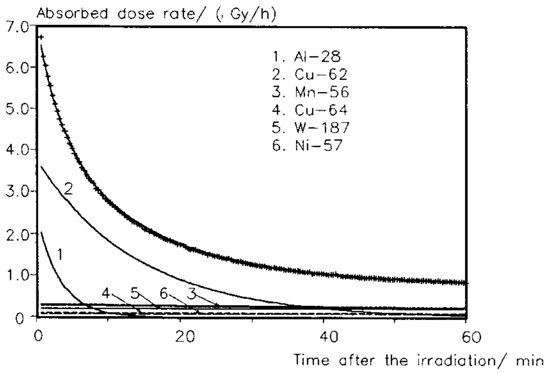

Figure 2 Absorbed dose rate at isocenter in the treatment room 0.5 to 60 min after a termination of the treatment with high energy photons.

The contribution from ^{28}Al ($T_{1/2}$=2.3 min) and ^{62}Cu ($T_{1/2}$=9.7 min) dominates the dose-rate immediately after the treatment. Later the contribution from radionuclides with longer halflives becomes important. E.g ^{187}W ($T_{1/2}$=24 h) and ^{57}Ni ($T_{1/2}$=36 h) contributes to the absorbed dose rate in the treatment room due to their relatively long halflives for several hours. At isocenter the absorbed dose rate is about two times higher than beside the treatment couch.

CONCLUSION

The total annual absorbed dose rate to the technicians was calculated to 2.0 mGy. The absorbed dose to the trunk and to the wrist are very similar. The dose to the hands are probably higher than to the wrist due to the β-particles emitting from the surface of accessories.

Induced radioactivity in the accelerator contributes with 1/3 and the radiation transmitted through the walls of the treatment room contributes with 2/3 to the absorbed dose to the technicians.

The contribution from induced radioactivity is rather constant for the different accelerators indicating the importance of radionuclides with long halflives as a source of radiation. This also means that the technicians is irradiated every time they enter the treatment room, not solely after treatments with high-energy x-rays.

ACKNOWLEDGEMENTS

This work has been supported by the Swedish Radiation Protection Institute. We also wish to thank all the technicians, nurses and hospital physicists participating in this study.

REFERENCES

Ahlgren L. and Olsson L.E. (1988). Induced activity in a high energy linear accelerator. Phys. Med. Biol. 33, 351-354.

Almén A., Ahlgren L and Mattsson S. (1991). Absorbed dose to technicians due to induced activity in linear accelerators for radiation therapy. Phys Med. Biol. 36 (6), 815-822.

Forkman B. and Petersson R. (1987) In: Handbook on Nuclear Activation Data. Technical Reports Series No. 273, IAEA, Vienna, 631-811.

LaRiviere Philip D. (1985). Radiotherapy technologist dose from high-energy electron medical accelerators. Health Phys. 49, 1105-1114.

Lederer L. P. and Shirley V. S. (1978). Table of Isotopes. New York, Wiley.