RADIATION DOSE RATES FROM PATIENTS UNDERGOING GALLIUM-67 CITRATE STUDY

K.Ejiri[1], S.Koga[2], T.Orito[1], H.Ohse[3], T.Nishimura[3], K.Yokoyama[3] and H.Toyama[2]

[1]Faculty of Radiological Technology, Fujita Health University School of Health Sciences,
[2] Department of Radiology, Fujita Health University School of Medicine,
[3]Fujita Health University Hospital, Toyoake, Japan.

INTRODUCTION

In 1990, ICRP widened the definition of the medical exposure[1]. When a patient is administered radiopharmaceuticals for his or her diagnosis or treatment, radiation exposure to the family attending the radioactive patients is regarded as medical exposure. Although definite dose limit to the medical exposure was not recommended by ICRP, the exposure should be kept as low as reasonably achievable. Therefore it might be necessary to set a dose constraint in nuclear medicine.

So, it is important to assess the magnitude of radiation exposure of the person who attend the patient. We have started some experimental and clinical studies on this subject. In the first stage of this studies, we chose Ga-67 citrate of a radiopharmaceutical for tumor imaging. We have performed to document the radiation exposures around the Ga-67 citrate patients and to estimate the radiation doses of the other persons who may come into close contact to them.

MATERIALS AND METHODS

In twenty three adult patients, administered Ga-67 citrate to diagnose for their examination, radiation dose rates ($\dot{X}$(mR/h)) around the patients were measured with three ionization survey meters (Aloka Model ICS-301). Records of the measurements were performed at times of 0.1 and 48.0 h after

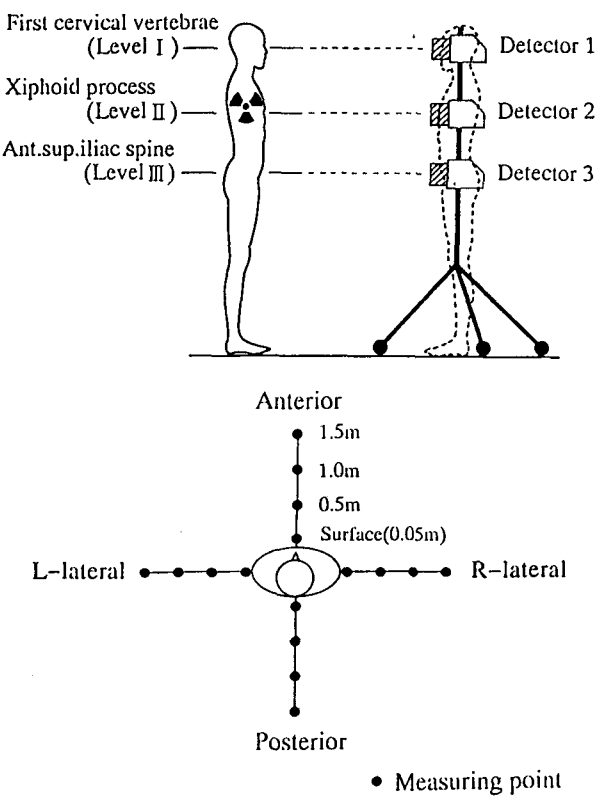

Figure 1. Detector arrangements for the dose estimation around the Ga-67 citrate patients.

injections of Ga-67 citrate.

The arrangements of these equipments were shown in Figure 1. X was normalized by the injection activity of 111 MBq and was converted into equivalent dose rate ($\dot{H}_{1cm}$ (μ Sv/h)) of 1cm in depth with a factor of 15.2 (μ Sv/mR). Biological half lives of 30 h (17%) and 613 h (83%) investigated by Evelyn E. Watson et al. [2] and physical half life (78.3 h) were used for the calculation of potential equivalent dose (H_{1cm}(μ Sv)) around the patient. The H_{1cm}s for a first week after the administrations of Ga-67 citrate were calculated from the effective decay constant (λ) of Ga-67 citrate and the initial $\dot{H}_{1cm}$s (A_0) of the measurements, using a equation:

$$H_{1cm} = A_0 (1-\exp(-\lambda \cdot t)) \lambda^{-1} \quad \cdots\cdots (1)$$

Where, the "t" is an integrating time to estimate the H_{1cm}. In figure 1, the broken line person was assumed to be a person exposed to the radiation from the Ga-67 citrate patient. To estimate the effective dose (E) of the other person who comes into close contact to the Ga-67 citrate patient, E of this broken line person at each distance from the patient was calculated by a equation:

$$E = 0.06H_a + 0.28H_b + 0.61H_c + 0.05H_{MAX} \quad \cdots\cdots (2)$$

H_a, H_b and H_c were corresponding to the H_{1cm}s calculated from the Xs of the detector 1, 2 and 3, respectively. H_{MAX} was defined as a maximum dose of H_a, H_b and H_c. Coefficients of 0.06, 0.28, 0.61 and 0.05 were obtained as partial sums of tissue weiting factors,as shown in Table 1.

Table1. Distributions of tissue weighting factors in recomendations-1990 of ICRP in areas with each detector.

	Detector1 (Head and Neck)	Detector2 (Thorax and Brachium)	Detector3 (Abdomen and Femur)	Max. of the three (Other tissue)
	0.05(thyroid)	0.12(lung)	0.20(gonads)	0.05(remainder)
		0.05(breast)	0.12(stomach)	
		0.05(oesophagus)	0.05(liver)	
			0.05(bladder)	
			0.12(colon)	
	0.012(bone marrow)	0.048(bone marrow)	0.06(bone marrow)	
	0.002(bone surface)	0.004(bone surface)	0.004(bone surface)	
	0.002(skin)	0.004(skin)	0.004(skin)	0.001(skin)
Total	0.066(~0.06)	0.276(~0.28)	0.608(~0.61)	0.051(~0.05)

RESULTS

The maximum $\dot{X}$ of 2.71 mR/h per 111 MBq was recorded at the Level II and the posterior projection. In all records, the $\dot{X}$s in posterior projection were similar to those in anterior, however, right and left lateral $\dot{X}$s were obviously lower than those. $\dot{X}$s at 0.5, 1.0, and 1.5 m from the patients were about one-fifth, one-tenth and one-twentieth of the surface one, respectively. The $\dot{X}$s in this investigation were obviously higher than the theoretical attenuation according to the inverse square law, when it was assumed that a Ga-67 citrate patient was a point source put in a free air. The retention rate calculated from $\dot{X}$s at 0.1 and 48.0 h after administration of Ga-67 citrate indicated a good agreement with that by Evelyn E. Watson et al.. H_{1cm} and E for a first week (168 h) were determined by the equation (1) and (2), as shown in Table 2. The maximum H_{1cm}

for a first week were 2216, 410, 172 and 89 μSv at distances of 0.05, 0.5, 1.0 and 1.5 m, respectively. These H_{1cm}s for a first week were equal to 82.4 percent of total radiation doses for unlimited time (∞ h).

Table2. Potential equivalent dose (H_{1cm}) and effective dose (E) around the Ga-67 citrate patient.

Area of dose evaluation	μ Sv/168h/111MBq (n=23)			
	Distances from Ga-67 citrate patient			
	0.05m	0.5m	1.0m	1.5m
Head and neck (H_{1cm})	1047	288	136	72
Thorax and brachium (H_{1cm})	2216	410	172	89
Abdomen and femur (H_{1cm})	1945	393	158	80
Effective dose (E)	1980	392	161	83

$$E=0.06H_a+0.28H_b+0.61H_c+0.05H_{MAX}$$

CONCLUSION

As far from 0.05 to 1.5 m, radiation exposure rates projected from Ga-67 citrate patients effectively reduce, however these rates are maintained for a long time. Accordingly an area around the patient is considered as a small hazard of radiations, particularly for the persons who may come into close contact to him. The patient provides only a small risk to otheres, but it should be recommend to aviod a long contact to the patient.

REFERENCES

1. 1990 Recommendations of the International Commission on Radiological Protection, Adopted by the Commission on November 1990. *Annals of the ICRP* 21, Nos.1-3 (1991)
2. Evelyn E. Watson, Roger J. Cloutier, and William D. Gibbs, Whole-Body Retention of 67Ga-Citrate. *J Nucl Med* 14, 840-842 (1973)