^{60}Co 不整形照射野での照射野係数について

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STUDIES ON FIELD FACTORS FOR ^{60}Co IRREGULAR FIELD IRRADIATIONS

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Summary

In this report, we analyzed field factors, which are important parameter in dose calculations, for ^{60}Co irregularly shaped fields.

Measured field factors for irregular fields were different from the field factors for equivalent square fields obtained from the standard field factor curve measured on square fields defined by installed collimator. They were almost settled on field factors for their open fields.

From the result of this experiment, we consider that in dose calculations for irregular fields it is better to use field factors not for equivalent square fields but for the open fields.

1. Introduction

It is essential in radiotherapy to protect normal tissue from radiation exposure. For this purpose, irregular field irradiation techniques are widely used in radiotherapy. In dose calculation for irregular fields, percentage depth dose, tissue-air ratio and tissue-maximum ratio are calculated in satisfactable accuracy by means of "area/perimeter (A/P)" method (equivalent square method), Clarkson's

method or others^{1)~7)}. Nevertheless, there are few report about the field factor for irregular field, which is one more important parameter in dose calculation. In this paper, we considered field factors for ^{60}Co irregular field irradiations.

2. Method

Following apparatus were used in this experiment.

Tele-cobalt unit: RTGS-2DM (Shimadzu)

(SAD=80 cm)

Ionization chamber: Victoreen 500

(probe: 550-6A)

(Volume=0.326 cm³, Stem effect=0.2%
for ^{60}Co)

Radiation output is dependent on the field size because of difference in scattered radiation dose, which are effective to the depth dose, from the collimation structure and others such as shield material surrounding the source. Theoretical calculation of these scattered radiation dose is very difficult because of complexity of inner structure such as collimator of radiotherapy instrument. We tried to calculate the dependence of scattered radiation dose upon the field size by means of a micro computer, but the correlation of amount of scattered radiation dose to field factors was wrong. Therefore in this experiment, we analyzed measured field factors, and discussed the method of field factor calculation for irregular field.

Field factor is defined that it is measured at the reference point and normalized to 1.0 for the output of $10 \times 10 \text{ cm}^2$ field.⁸⁾ On the ^{60}Co unit, it is convenient for dose calculation to measure the field factor in air, if the 'Output' is measured in air. To estimate the influence of secondary electron⁹⁾¹⁰⁾ when field factors are measured in air, we compared the field factors measured in air with the field factors which had been measured at 5 cm depth in water and divided by corresponding TAR. Consequently, both field factors coincided within 0.5%, and we considered the influence of secondary electron for field factors to be negligible. Therefore in this experiment, all measurement were performed in air. In addition, field factors in this paper were represented as a function of "area/perimeter (A/P)" which were widely applied.

At first, we made a standard field factor curve which was measured on square fields ($4 \times 4 - 26 \times 26 \text{ cm}^2$) defined by installed collimator.

Next, we measured following three kind of field factors, and compared with the standard field factors, respectively.

- 1) Field factors for rectangular field (not square) by installed collimator.

- 2) Field factors for square field by lead block. Field size by installed collimator (open field) are constant.

- 3) Field factors for five kind of irregular fields illustrated in Fig. 3.

3. Result and Discussion

Fig. 1 show the standard field factor curve obtained from the measurement on square fields by installed collimator and field factors measured on various rectangular fields (not square). If field factors for fields by installed collimator are represented as a function of A/P or equivalent square, their deviation from the standard field factors are smaller than 1% at maximum.

The variation of field factors are considered due to variation of amount of scattered radiation, which are effective to the depth dose, from the collimator system and others. When the field size is larger, the chance of scattering is increased. It is seen from Fig. 1 that this relationship could be approximated as a function of A/P or equivalent square.

Fig. 2 show field factors for square fields by lead block under the condition that the open

Fig. 1. Graph showing the standard field factor curve measured on square fields defined by installed collimator and field factors measured on various rectangular fields (dot).

Fig. 2. Graph showing field factors measured on square fields defined by lead block. The open field is constant.

Fig. 3. Diagrams illustrating five kind of irregular fields used on measurement of field factors.

field size (field by installed collimator) is constant. Field factors for square fields by lead block (except for extreme case) are similar to the field factors for standard field factor for the open fields. This result is considered due to correlation between additional scattered radiation from lead block, which are effective to the depth dose, and interception of scattered radiation from inner structure by lead block. Therefore, when the field size by lead block is almost identical with the open field, its field factor is slightly larger than that of the open field. On the other hand, when the field size by lead block is much smaller than the open

Table 1. Field factors for irregular fields illustrated in Fig. 3; column 1: classification of irregular shape correspond to Fig. 3. "h" are cut off length by lead block shown in Fig. 3. Column 2: cut off length by lead block shown in Fig. 3, "r". Column 3: A/P value for each irregular field. Column 4: measured field factors. Column 5: field factors obtained from the standard field factor curve at corresponding A/P. Column 6: % deviation of field factors in column 5 from measured field factors. Column 7: field factors for the open field size ($15 \times 15 \text{ cm}^2$). Column 8: % deviation of open field factors from measured field factors.

	r	A/P	Field factor	Eq. sq. F.F.	% err.	open F.F.	% err.
A	2.5	3.790	1.047	1.042	0.5	1.040	0.7
	5.0	3.723	1.047	1.039	0.8	1.040	0.7
	7.5	3.540	1.045	1.035	1.0	1.040	0.5
	10.0	3.232	1.042	1.026	1.6	1.040	0.2
	12.5	2.788	1.026	1.010	1.6	1.040	1.4
	Average				1.07		0.67
B	2.5	3.833	1.045	1.042	0.3	1.040	0.5
	5.0	3.694	1.046	1.039	0.7	1.040	0.6
	7.5	3.295	1.044	1.027	1.7	1.040	0.4
	10.0	2.589	1.042	1.003	3.9	1.040	0.2
	12.5	1.516	1.022	0.960	6.5	1.040	1.8
	Average				2.59		0.67
C	2.0	3.683	1.048	1.038	1.0	1.040	0.8
	4.0	3.483	1.048	1.033	1.5	1.040	0.8
	6.0	3.150	1.045	1.023	2.2	1.040	0.5
	Average				1.52		0.67
D	2.0	3.617	1.048	1.037	1.1	1.040	0.8
	4.0	3.217	1.050	1.025	2.4	1.040	1.0
	6.0	2.550	1.045	1.002	4.3	1.040	0.5
	Average				2.60		0.74
E h=2.5	2.5	3.542	1.041	1.035	0.6	1.040	0.1
	5.0	3.333	1.041	1.030	1.1	1.040	0.1
	7.5	3.125	1.042	1.023	1.9	1.040	0.2
	10.0	2.917	1.042	1.016	2.6	1.040	0.2
	12.5	2.708	1.043	1.008	3.5	1.040	0.3
	Average				1.91		0.17
E h=5.0	2.5	3.333	1.042	1.030	1.2	1.040	0.2
	5.0	2.917	1.041	1.016	2.5	1.040	0.1
	7.5	2.500	1.041	1.000	4.1	1.040	0.1
	10.0	2.083	1.039	0.985	5.5	1.040	0.1
	12.5	1.667	1.039	0.968	7.3	1.040	0.1
	Average				4.11		0.12

field, its field factor is smaller than that of the open field.

In **Table 1**, measured field factors for five kind of irregular fields illustrated in **Fig. 3** are shown (column 4). In addition, field factors obtained from the standard field factor curve at corresponding A/P (column 5), field factors for the open field size ($15 \times 15 \text{ cm}^2$) (column 7) and their % deviation from measured field factors (column 6, 8) are tabulated. Errors of field factors for irregular fields obtained from the standard field factor curve to measured field factors and considerably large on average. Furthermore, measured field factors are different from field factors for equivalent square fields by lead block, depending upon the shape of irregular field. This result are considered because of difference of correlation between the scattered radiation increment due to lead block and the interception of scattered radiation from installed structure by lead block depending upon the shape of irregular field.

When field factors for the open fields, instead of field factors for equivalent square fields, are used in dose calculation, errors are decreased within 1% on average.

From above result, we consider that field factors for ^{60}Co irregular fields by lead block are almost settled on field factors for the open fields, and that it is better to use field factors not for equivalent square fields but for the open field in dose calculation for irregular field irradiations except for extreme case. In extreme case such as a split field or an irregular field of which beam center is shielded by lead block, it is better to measure case by case. But, we cannot absolutely say "from what irregular shape, it is better to measure", because this problem is correlated with accuracy of other calculation parameter such as PDD, TAR, or TMR etc.

4. Conclusion

In this paper, we analyzed field factors measured on ^{60}Co irregular shaped fields by lead block.

Field factors depend on amount of scattered radiation, which are effective to the depth

dose, from collimating system and other inner structure. In irregular fields, field factors depend on correlation of scattered radiation increment due to lead block with interception of scattered radiation from installed structure by lead block. But this correlation varied complicatedly depending upon the shape of field, therefore it was difficult to simulate correctly the interrelation between field factors and amount of scattered radiation.

In actual measurement, field factors for irregular fields, except for extreme case, by lead block were almost settled on field factors for their open fields by installed collimator.

We consider that in dose calculation for irregular field irradiations it is better to use field factors not for equivalent square fields but for the open fields by installed collimator.

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