Survey of safety regulation and evaluation of the shielding facility for the medical linear accelerator

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Introduction

- Recent technologies of radiotherapy such as Intensity-modulated radiotherapy, Tomotherapy and Cyberknife had advantage of the faster and higher dose delivery to patient. The special consideration to design the facility for these technologies was described in NCRP repot No.151 (published in 2005) and IAEA Safety Report No.47 (published in 2006). We reviewed the shielding design of operating facility and compared with the recommendation from these reports.

Methods

- The multi-institutional survey was performed to review the workload (W [Gy/week]), IMRT factor (F), primary barrier (B_{pri}) against primary beam and secondary barrier (B_{sec}) against scattering (B_{ps}) and room leakage (B_L) described in radiation safety report. In survey, 10 facilities for linear accelerator for IMRT, 5 facilities for Tomotherapy, 3 facilities for Cyberknife from 10 institutes was compared.

$$B_{pri} = \frac{P \times d^2}{W \times T \times U},\ B_{ps} = \frac{P \times \frac{400}{F} \times d_{sca}^2 \times d_{sec}^2}{\alpha \times W \times T},\ B_L = \frac{1000 \times P \times d_{sec}^2}{W \times T}$$

- The IMRT factor (F) was described in reports from NCRP and IAEA. It was determined as a ratio of the dose delivery monitoring unit between the technology and conventional 3D conformal radiotherapy. The factor was not a single value, a wide range of values because It was dependent on radiation delivery technology and the machine designed by manufacture such as Varian and Elekta.

$$F = \frac{MU_{IMRT}}{MU_{Conventional}}$$

- The thickness of primary barrier (B_{pri}) was determined by the radiation shielding design goal, the shielding material, the workload (W), a use factor (U) and a occupancy factor (T). The radiation shielding design goal was the recommended value in legal. And the workload (W) was the weekly expected dose delivered with maximum output of the machine. It was based on the spec of machine and the usage plan of machine per week. Other factor U and T was determined by the situation around the facility and the recommended value from reports.
- The thickness of secondary barrier (B_{sec}) was a conservative value between barriers against scattering and leakage radiation. Different with 3DCRT, the IMRT factor (F) was multiplied to the leakage workload (W_L) because the advanced technology such as Tomotherapy and Cyberknife produced more leakage radiation.

Results

- We found the variance of these values among technologies and institutes. IMRT factor applied to primary barrier and scattering barrier in the part of case. This decision was enough conservative in the aspect of the radiation protection but was not reasonable because the recommendation from NCRP and IAEA had been misinterpreted to the shielding designer. And the part of facilities was designed with an old recommendation of the radiation shielding design goal from NCRP, IAEA because it was designed before the related legal regulation revision. But the design was enough conservative to the recent regulation.

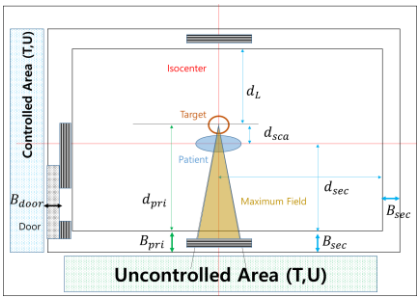

Figure 1. considering parameters to design the shielding structure of radiotherapy facility

Type	W, W_L	F	Apply F to
L	11500, 66700	7	B_L for high energy
L	1000, 2200	5	B_L , B_{ps} for dual energy
L	1000, 1800	5	B_L for high energy
L	50000	1	Nothing for high energy
L	1000, 4800	5	B_L for dual energy
L	1100, 4180	5	B_L for dual energy
T	95000	15	B_{pri} , B_L , B_{ps}
T	140000	15	B_{pri} , B_L , B_{ps}
T	10000	15	Manufacture

Table 1. Survey about (leakage) workload and application of IMRT factor. Type L was IMRT linear accelerator. Type T was Tomotherapy.

Conclusion

- We reviewed the guideline from international agency and the facility design of multi institutes. In the result, some misinterpretation of the international recommendation found and we saw the necessity of clear guideline about recent technology.

REFERENCES

[1] NCRP Report No. 151(2005), Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities
[2] IAEA Safety Reports Series No. 47(2006), Radiation Protection in the Design of Radiotherapy Facilities

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