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Protection of Critical Organs by Dynamic Conformal Radiotherapy with MLC

Yukio Uchiyama, Takashi Kubota, Minoru Kawai ,
Hikaru Oosaki, and Nobukazu Fuwa

Dept. of Radiation Oncology, Aichi Cancer Center Hospital, Nagoya, Japan

Introduction

Hollow-out technique is important method in radiation therapy for the protection of critical organs from radiation damage like, the crystalline lenses under the radiotherapy of maxillary cancer or the spinal cord under the radiotherapy of esophagus cancer. Hitherto absorber attached to the head of a linac is commonly used, however it is not always applicable since there are some restrictions on shaping of the absorber, organs to protect, and patient-setup. The multi-leaf collimator (MLC) is installed in state-of-the-art linacs. Each leaf of MLC can move across its center of the field. Critical organs can be protected by utilizing the MLC.

At the same time, radiation treatment planning (RTP) system has changed into 3-D capability to calculate non-coplanar and dynamic conformal planning. Installing a new program added to the RTP system makes it easier to protect critical organs as you want. I studied the practical use of the computer controlled MLC (I call it MLC method) through dose distribution measurements and clinical applications for organ protection without hollow-out absorber.

Method

I studied as follows

1. Development of a program for MLC method
2. Accuracy examination of the dose distribution calculation
3. Phantom measurement
4. Clinical applications.

Development of a program for MLC method: In 1990 a RTP system was developed in Aichi Cancer Center Radiation Oncology Systems (ACCROS). At that time it adopted hollow-out technique. In 1996 the RTP system shifted to FOCUS, which was 3-D system and applied to hollow-out absorber of lead, tungsten, and zinc. In 1997 we decided specifications of MLC method utilizing a multi-leaf collimator which can move across its center of the field. In February 1998 it was installed. The bugs were fixed until June. In February 1999 we started to apply the method to clinical use.

Systems: The linac (Clinac2100C) of VARIAN and the RTP system (FOCUS) of CMS are linked on-line to ACCROS to transfer data.

Result

Accuracy of the dose distribution calculation: To examine the accuracy of the dose distribution, I compared hollow-out technique with MLC method by photographic dosimetry and 3-D calculation of the RTP system based on Clarkson method. The two distributions are almost the same but the curves of MLC method are more appropriate than hollow-out both in high dose area and in low dose area, so MLC method has the advantage to protect a critical organ. There are some differences in detail dose distributions, so the comparison of those without protecting a critical organ is made for reference. The gradient of the isodose curves by photographic dosimetry is gentle. Difference of the curves in high dose area is a few mm, and that in low dose area is 5mm in comparison of two data. I observed similar

inclination in the curves with protecting a critical organ. Consequently I concluded 3-D calculation of the RTP system using Clarkson method is acceptable in clinical use.

Phantom measurement: The difference between the cases is within 0.5%. The cases are the exposure dose with no absorber, with MLC method of 1.5cm, 2.0cm, and 3.0cm in blocked diameter, and that with hollow-out technique of same size respectively. I believe it is accurate enough. I did other experiments, with changing geometrical conditions (like the diameter of the target, the blocked diameter, and the position being blocked). In these experiments, the measured dose and the calculated dose show similar results. I obtained the doses at the organ protected, with changing block diameters (1.5cm, 2.0cm, and 3.0cm). The doses vary from 13% to 17% at the isocenter. This proves the effect of the technique, as I expected. I am concerned about the difference between the measured dose and the calculated dose. The calculated dose shows smaller value than the measured. I assume the reason of it is the algorithm of the RTP system estimating the scattered rays effect lower than actual. I think it can be ignored.

Clinical applications: I had a plan to utilize MLC method clinically this year, and actually it has been applied to 2cases (i.e. lung cancer at the bronchus, and the retroperitoneal lymphnodes). Accordingly, when the target dose is 60 Gy, the spinal code gets only 12Gy. The irradiation time of 5 minutes is as twice long as hollow-out technique. However, the overall time is reduced by 5 minutes because there is no need of complicated machine setup for attaching absorber. Also it is safer for patients with eliminated accessories attached to the linac head.

Discussion

Advantage of MLC method: The advantage is as follows; Maintaining clearance between a linac head and a patient during the rotation of the linac because of no accessories attached to the linac head, No need to make absorbers, It is very difficult to shape absorbers, when the shape is thick or thin in particular, Shorter time of machine setup by eliminating absorbers, It usually takes 5 minutes to attach absorbers, or 10 minutes for new patients in particular, Safety for patients. No accessories attached to a linac head means no possibility of dropping absorbers on patients accidentally.

Problems of dynamic conformal radiotherapy: In the case of lung cancers which are sometimes unsuitable for surgery because of complications or advanced age, the given dose should be limited to avoid the damage of normal tissue. Then I think it important to increase the given dose by any means for improving the local control accordingly. Non-coplanar conformal radiotherapy can irradiate a target from any direction three-dimensionally. As the result, increasing the given dose becomes possible. However it is impossible to judge whether the target is surely irradiated from any direction as planned, if it is verified only by usual check film. I studied how much I need to take into account as safety margin around Clinical target volume (CTV). To keep 5% accuracy of cumulative error, the patient positioning error should be within 5mm, and the fluctuation per day should be within 2mm. We expect good treatment results for lung, but it would be different story to discuss the lower part of the lung, which moves by breathing and the other part, which does not very much.

Conclusion

MLC method is more effective than hollow-out technique in several aspects ; less exposure dose at the organ you need to protect, good control in the shape of the cold area and the one of the organ to protect, and less total radiotherapy time for each patient. I believe that the MLC method will be very powerful way to protect critical organs like kidney, rectum, and bladder. In other words this is a simple and easy way of Intensity Modulation Radiotherapy (IMRT) which is under study in Europe & U.S.A. recently.