A Commissioning of 3D RTP System for Photon Beams

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ABSTRACT

The aim is to urge the need of elaborate commissioning of 3D RTP system from the firsthand experience.

A 3D RTP system requires so much data such as beam data and patient data. Most data of radiation beam are directly transferred from a 3D dose scanning system, and some other data are input by editing. In the process inputting parameters and/or data, no error should occur. For RTP system using algorithm-based-on beam-modeling, careless beam-data processing could also cause the treatment error.

Beam data of 3 different qualities of photon from two linear accelerators, patient data and calculated results were commissioned. For PDD, the doses by Clarkson, convolution, superposition and fast superposition methods at 10 cm for 10×10 cm field, 100 cm SSD were compared with the measured.

An error in the SCD for one quality was input by the service engineer. Whole SCD defined by a physicist is SAD plus d_{max}, the value was just SAD. That resulted in increase of MU by $100\times((1+ d_{max}/SAD)^2-1)$ %.

For 10×10 cm open field, 1 m SSD and at 10 cm depth in uniform medium of relative electron density (RED) 1, PDDs for 4 algorithms of dose calculation, Clarkson, convolution, superposition and fast-superposition, were compared with the measured. The calculated PDD were similar to the measured. For 10×10 cm open field, 1 m SSD and at 10 cm depth with 5 cm thick inhomogeneity of RED 0.2 under 2 cm thick RED 1 medium, PDDs for 4 algorithms were compared. PDDs ranged from 72.2% to 77.0% for 4 MV X-ray and from 90.9% to 95.6% for 6 MV X-ray. PDDs were of maximum for convolution and of minimum for superposition. For 15×15 cm symmetric wedged field, wedge factor was not constant for calculation mode, even though same geometry. The reason is that their wedge factor is considering beam hardness and ray path. Their definition requires their users to change the concept of wedge factor.

RTP user should elaborately review beam data and calculation algorithm in commissioning.

Keywards: 3D radiation treatment planning, photon beam data, manual data, algorithm, commissioning

1. INTRODUCTION

A three-dimensional radiation treatment planning system (3D RTPS) needs an elaborate program and much data. The program includes so many algorithms such as dose and MU calculation, patient data input, contouring, displaying of patient and beam geometry, dose distribution, plan comparison, etc. The data could be classified into 5 groups; 1) beam data, 2) patient data, 3) contours, 4) geometry data and 5) data of dose modifiers. Some data are input through on-line, but others are input manually.

There could be possibilities of being errors in the 3D RTP program and also, possibilities of making error(s) of dose, MU and beam geometry. Such errors are not easy to be detected because of so many data. Any error of a RTP system as well as radiation therapy might bring severe or fatal consequences to radiation therapy patient. So, if there is any error in an RTPS and patient data, all patients to be treated by plan based-on the data would be suffered until the error would be detected and corrected.

RTPS should be free from error. For the purpose, before clinical use, beam data should be transferred (or input) to a new installed RTPS, and whole functions of the RTPS should be checked by a qualified medical physicist.

The author had experience of commissioning a new installed RTPS. He had found some errors of the RTPS. The errors will be reported.

2. OBJECT AND METHOD

Measured data by 3D water phantom (Blue phantom, Wellhöfer, Germany), PDDs and dose profiles at 100 cm SSD of open and wedge fields of 3 different qualities of X-ray beams from two linear accelerators, were transferred to 3D RTPS (Focus, CMS, USA) on-line. The RTPS uses two kind of modeled beam data of both open and wedge fields; Clarkson- and convolution- (or superposition-) based-on modeled beam data. Beam parameters such as collimator scatter factor (S_c), phantom scatter factor (S_p), source chamber distance (SCD) for defining MU, wedge transmission factor and tray factor, and machine parameters such as gantry, collimator and couch positions, source diaphragm distance (SDD), source tray distance (STD) and wedge direction were input manually. CT and MRI data are imported through network. Both automatic and manual contouring is possible. Both automatic and manual field shaping is also possible.

To confirm the accuracy of SCD, MU calculated using Clarkson-modeled beam in uniform phantom of relative electron density 1.000, 10 cm square field for 100 cm SSD were compared with measured one. The accuracy of S_c and S_p was checked using MU and PDD at several depths for 5, 10 and 20 cm square fields for 100 cm SSD in uniform phantom of relative electron density 1.000.

Four dose calculation algorithms were compared using phantom of uniform relative electron density of 1.000 and phantom with an heterogeneous material for both SSD (1 m) and SAD technique. The inhomogeneous material was a 5 cm thick layer of air equivalent or relative electron density (RED) 0.2 (cork equivalent). The depth of upper surface of an inhomogeneous material was 2 cm. When the dose at 10 cm depth was 1 Gy, MU calculated using each algorithm was compared with MU based on measurement in same situation.

CT number of water was checked at CT and RTPS sites. Dimension and shape of both CT and MRI were also checked. How the change of shape of copied field affects the original field was checked. And how the change of shape of fields in a rival plan affects the original plan was also checked.

3. RESULTS

Machine parameters manually input such as positions of gantry, collimator and couch, position and direction of wedges, source-axis distance (SAD), source-diaphragm distance, source-tray distance, and source-calibration-point distance (SCD) were checked. In the institute, SCD was defined as sum of SAD and dose-maximum depth. SCD of one quality, however, was equal to SAD. For the beam of that quality, dose error by

$100\times((1+ d_{max} /SAD)^2-1)$ %

is introduced in dose calculation, if that is not corrected.

For homogeneous material of unit relative electron density, dose and MU of open field of 10 cm for both SSD and SAD techniques were nearly independent of dose calculation algorithms. For homogeneous material, dose and MU of wedge field of 15 cm for SSD techniques were nearly independent of algorithms but those for SAD technique showed error of maximum 3.6% for 4 MV, 60° wedge. For heterogeneous material of 0.2 relative electron density, dose and MU of open field of 10 cm for SSD techniques were nearly independent of algorithms, but those for SSD techniques showed difference of 9.3% between convolution and superposition modeling for 4 MV X-ray.

CT numbers, size and shape of both CT and MR images imported from CT and MR through DICOM were conserved.

Changing of the shape of copied beam affected the shape of original beam even though both of them are independent from each other. After a plan was saved, changing of a beam shape also affected the original plan. At present, the only solution is to set new beam.

4. CONCLUSION

Four items on commissioning process of 3D RTPS were considered. Following conclusions were obtained from them.

1) The error of machine parameters manually input can cause significant dose error.
2) In each condition of homogeneity or heterogeneity of tissue, dose calculation algorithm that could minimize dose error should be selected.
3) CT number, shape and dimesion of CT and MR image should be checked.
4) The effect of changing beam shape on original plan or beam should be checked.

5. REFERENCES

1. Morgan, H.M.: Treatment planning. in *Physical Aspects of Quality Control in Radiotherapy.* ed. by Mayles, W.P.M., Lake, R., McKenzie, A., et al. IPEM Report No. 81, 1999, pp60-95
2. Thwaites, D., Scalliet, P., Leer, V.W., et al.: Quality assurance in radiotherapy. ASTRO Advisory Report, 1994
3. Kutcher, G.J., Coia, L., Gillin, M., et al.: Comprehensive QA for radiation oncology: Report of AAPM Therapy Committee Task Group 40, Med. Phys. 21:681-818, 1994
4. van Dyk, J., Barnett, R.B., Cygler, J.E., et al.: Commissioning and quality assurance of treatment planning computers. Int. J. Rad. Oncol. Biol. Phys. 26:261-273, 1993