DOSIMETRY AUDITS IN RADIOThERAPY:
15 years of experience and lessons learnt

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Introduction

Radiotherapy (RT) is a highly effective treatment for cancer worldwide. Over the time though, the RT machines and procedures are getting improved, because modern and more advanced techniques (IMRT, VMAT, SRS, SRT, etc.) are introduced. Although, all RT techniques applied bring great potential benefits, sometimes they can lead to mistakes or failures. To minimize the likelihood of harmful effects and to strengthen the safety culture in RT, external dosimetry audits (DA) have been established for RT centers. Since 2002, the Greek Atomic Energy Commission (EEAE) provides dosimetry audits of level I, II and III, and recently IV1 in MV photon and electron beams in all RT centers of the country. The aim of this work is to present the situation of RT in Greece and its quality improvement over the years, as derived from the audits results. The future goal of EEAE is to widen the type of its audits, in order to keep up with the forthcoming technologies.

Results

The accuracy of dosimetry under reference and non-reference conditions for photon and electron beams has improved over the years. Latest DA within 2017, revealed that only 1.6% of the photon beams and 1.2% of the electron beams gave non-acceptable (> 5%) dose audit results under the reference conditions. The assessment of the TPS output for 1134 beams (790 open, 344 wedged) over the last 15 years was acceptable in 95% and 84% of the open and wedged beams, respectively. The number of non-acceptable results decreased progressively with time.

Material & Methods

DA were conducted by means of on-site visits. The audit levels applied, in sequence, were: Mechanical and functional tests of the RT machine, reference (absolute and relative)1 dosimetry, beam and treatment planning system (TPS) output measurements under reference and non-reference conditions, end-to-end tests for the assessment of the TPS dose calculations and the entire RT treatment chain accuracy, applied by the RT center, in basic and advanced RT techniques through 1-, 2- and 3-D dosimetry. Measurements were compared to the stated by the RT center values according to acceptance and tolerance criteria. Uncertainties were estimated according to the GUM5.

Conclusions

Dosimetry audit was proven to be a valuable tool for the improvement of quality in radiotherapy. Dosimetry accuracy was verified in the gross majority of RT centers. Discrepancies and inadequate practices were detected, presenting a decreasing incidence over the years. Guidance and recommendations provided to centers, helped to improve dosimetry practices and verified that the quality assurance procedures in an institution are essential for achieving the required accuracy and safe operation. Results of this study suggest that challenges exist in TPS commissioning, especially for small fields, and there are challenges in multicenter comparison for complex dose distributions and complexity metrics.

References

1 J. Lapin, Setting up a Dosimetry Audit Centre: Infrastructure and Resources. 2016, IAEANewsletter No. 68, p. 9-10, June 2017.

Fig. 1. Typical VMAT with a circular treatment volume is shown. The left image presents the fluence distribution measured by IAEA in the CIRS 801 phantom, while the right in the center presents the dose distribution as calculated by the TPS of the RT center. Gamma index map (3%/3mm) with values of measured (solid line) and calculated (dashed line) percentage dose differences superimposed on the reference to facilitate comparison is presented in the right figure.

Fig. 2. The percentage of (a) photon beams, (b) electron beams and (c) TPS output measurements that exhibited non-acceptable reference dose during the four dosimetry audit rounds, as a percentage of the respective conducted within each round. The (d) 67% limit is applied to these data.