Upgrading QA/QC Programme in Radiation Therapy in Croatia: Results of the IAEA CRO 6008 Project

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INTRODUCTION

Modern radiation therapy requires utilization of sophisticated equipment in radiotherapy enviroment as well as implementation of advanced external beams techniques such as 3D conformal radiotherapy and intensity modulated radiotherapy. This enables better optimization of dosimetric plan which might considerably improve the outcome of radiotherapy treatment. Therefore, radiotherapy chain is constituted of large number of activities involving different professionals (radiation oncologists, radiation technologists, physicists) and possibility for random as well as systematic error is significant. This necessitates quality control (QC) of every part of the radiotherapy process, as it helps to detect errors and provides instant remedy. International Atomic Energy Agency (IAEA) CRO 6008 project: 'Upgrading QA/QC in two radiotherapy departments in Croatia' started in 2008 at radiotherapy departments of University hospitals Osijek and Rijeka to upgrade existing QA/QC programmes in those two hospitals with intent to work on upgrading QA/QC on national level.

OBJECTIVES

We are presenting the work in IAEA project with goal to upgrade and harmonize existing QA/QC programmes at radiotherapy departments of two major regional centres. At the same time, survey of QA/QC written protocols existence was conducted among all radiotherapy departments in Croatia [1]. The lack of written protocols was identified and the joint programme is planned to be extended to the national level. Furthermore, to survey the situation in radiotherapy and to promote importance of the QA/QC programme, two types of audits, according to the protocols developed during the project, were conducted [2]. One audit judged mechanical and radiation parameters of linear accelerators and simulators [3] and the other was dedicated to audit different parameters of treatment planning systems (TPS) according to the IAEA guidelines [4, 5]. One of the audits purposes was on-site sharing experiences between medical physicists working at radiotherapy departments, especially in the light of national equipment renewal. This was also an effort on building awareness of QA/QC importance which would hopefully result in establishing uniformity in QA programmes among radiotherapy centres in Croatia. The next step following this project will be aimed to further upgrade and harmonize QA/QC programmes all over Croatia using help of radiation protection regulatory body and national professional societies.

METHODS

We started our work before the large equipment renewal in all radiotherapy centres in Croatia in order to assure the adoption of working QA/QC programmes in the new surround. Firstly, only equipment QC protocols were done and afterward whole radiotherapy QA/QC programme was harmonized between two major regional hospitals. According to this, written protocols were made for daily, weekly, monthly, quarterly and yearly procedures. In the same time, to obtain insight into the current employed protocols at national level a questionnaire was made and it was sent to all radiotherapy institutions in Croatia. It concerned different parameters of QC, protocols, methods, frequencies, equipment used and time required for the test, as well as tolerance/action levels and personnel responsible for performing QC tests. The next step was a survey of equipment QC in all centres. Tests were performed in six radiotherapy centres and included nine linear accelerators and six conventional simulators. Test procedures (mechanical and radiation accuracy) were based on well-established QC protocols at University hospitals of Rijeka and Osijek. All QC manuals are publicly available through websites. Four national workshops were organized in cooperation with National societies of technologists and medical physicists and radiation protection regulatory body. After the renewal of radiotherapy equipment in Croatia we performed dosimetric verifications in four Croatian radiotherapy centres. It was done according to the IAEA guidelines [4, 5]. After a basic dosimetric verification of TPS in homogenous (water) phantom, a dosimetric verification in inhomogeneous anthropomorphic phantom CIRS Thorax (CIRS Inc., Norfolk) was performed. For this purpose 14 tests were defined. Dosimetric verification was carried out on four dual-photon-beam linear accelerators (6MV and 18MV), three Siemens Oncor Expressions and one Elekta Synergy in 4 out of 6 Croatian radiation therapy departments. All surveyed centres use CMS XiO treatment planning system (Elekta AB, Sweden) and the most precise algorithm offered by the system (multigrid superposition). For the evaluation of measured (Dmeas) and calculated (DTPS) values the same criteria as specified in IAEA TRS 430 were employed:

$$\Delta(\%) = \frac{(D_{TPS} - D_{meas})}{D_{meas,ref}} \times 100$$

RESULTS

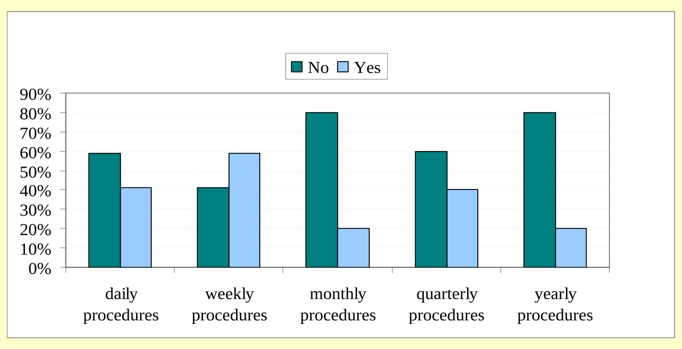

Fig.1 Existence of written protocols in radiotherapy centers in Croatia

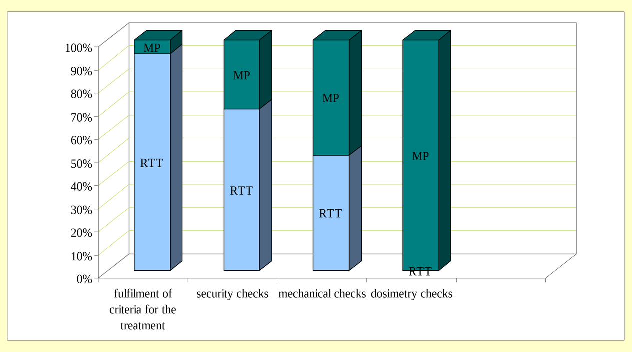
Fig.2 Personnel involved in performing QC checks. MP-medical physicist, RTT-radiation therapist

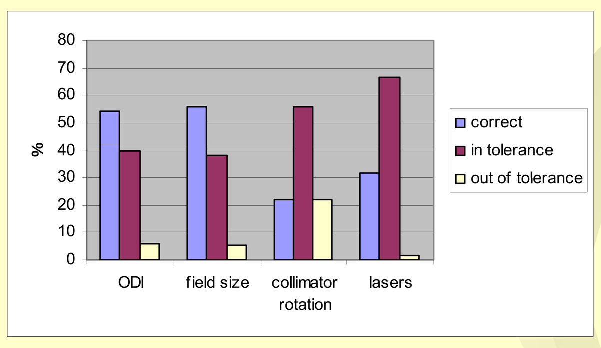

Fig.3 Results of mechanical accuracy tests performed on linear accelerators.

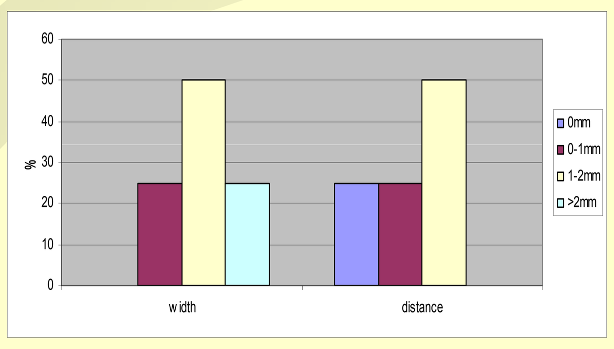

Fig.4 Results of multi-leaf collimator (MLC) parameter tests performed on linear accelerators

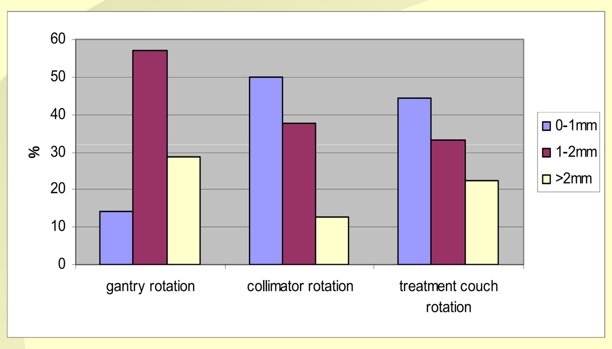

Fig.5 Results of radiation accuracy tests performed on linear accelerators

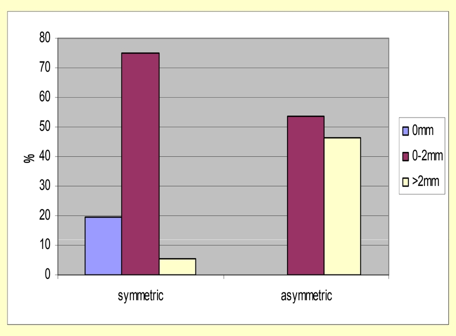

Fig.6 Results of light/radiation coincidence tests performed on linear accelerators

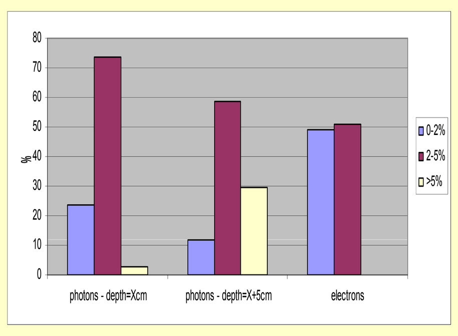

Fig.7 Results of flatness tests performed on linear accelerators

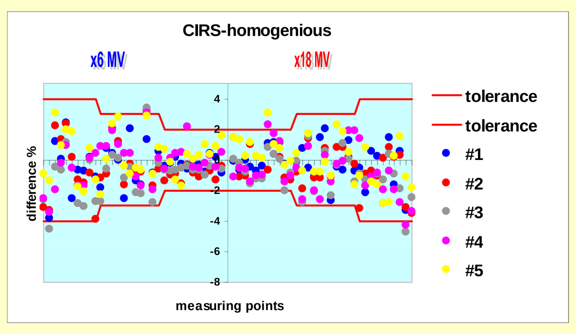

Fig.8 Differences between measured and calculated values for both photon energies in water equivalent part of the phantom for 5 linear accelerators. Tolerances are given by the red lines

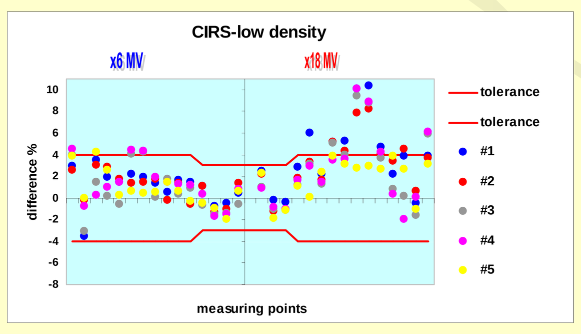

Fig.9 Differences between measured and calculated values for both photon energies in low density part of the phantom for 5 linear accelerators. Tolerances are given by the red lines

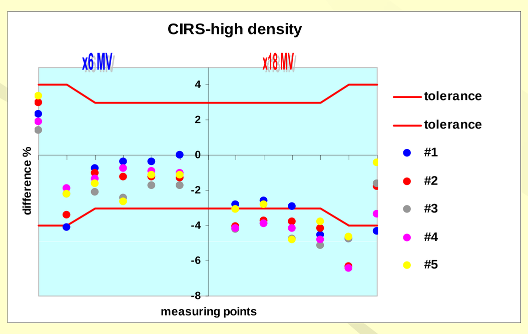

Fig.10 Differences between measured and calculated values for both photon energies in high density part of the phantom for 5 linear accelerators. Tolerances are given by the red lines

Linear accelerator	Energy	Water equivalent Δ/%	Low density Δ/%	High density Δ/%
1	6	-0,126	1,726	-1,385
	18	-0,317	4,710	-4,295
2	6	0,336	2,183	-1,253
	18	-0,292	3,560	-4,922
3	6	-0,177	1,488	-1,064
	18	-0,383	4,170	-4,181
4	6	-0,606	1,285	-1,427
	18	-0,563	3,746	-4,483
5	6	0,302	1,966	-1,290
	18	-0,408	3,453	-4,954

Table 1. Averaged differences for all measurements done in raw water, low density and high density parts of the phantom for low and high energy photon beams.

DISCUSSION

Though the CRO 6008 project was done in order to harmonize QA/QC programmes between two major regional radiotherapy centres, national survey showed lack of written QC protocols and QA programmes in radiotherapy departments in Croatia. This moved the project team to work also on surveying the situation and to promote QA/QC importance using top-to-bottom approach (national workshops, availability of QA/QC programmes made by two centres, cooperation with radiation safety regulatory body) and bottom-to-top approach (measuring different parameters from QC protocols in all radiotherapy centres in Croatia). Analyses of collected mechanical, radiation and security parameters (Figures 1-7) at radiotherapy units (linear accelerators and conventional simulators) showed variety of results for tested parameters. Some out-of-tolerance parameters were found and corrections were recommended. Audit of TPSs (Figures 8-10 and Table 1) showed that commissioning of the new equipment in 2011 were done in a good manner in all centres but also showed the limitations of particular system. It can be also concluded that more attention is given to the dosimetry than to the quality of mechanical and radiation parameters.

CONCLUSIONS

One of the audits purposes was on-site sharing experiences between medical physicists working at radiotherapy departments, especially in the light of national equipment renewal. This was also an effort on building awareness of QA/QC importance which would hopefully results in establishing uniformity in QA programmes among radiotherapy centres in Croatia. The next step following this project will be aimed to further upgrade and harmonize QA/QC programmes all over Croatia using help of radiation protection regulatory body and national professional societies.

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