Statistical analysis of quality control measurements in IMRT for head and neck and prostate cancer

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Introduction:

Intensity Modulated Radiotherapy (IMRT) is a technique introduced to shape more precisely the dose distributions to the tumour, providing a higher dose escalation in the volume to irradiate and simultaneously decreasing the dose in the organs at risk which consequently reduces the treatment toxicity[1-4]. This technique is widely used in prostate and head and neck (H&N) tumours[4-6]. Given the complexity and the use of high doses in this technique it's necessary to ensure a safe and secure administration of the treatment, through the use of quality control programmes for IMRT[2,6-7].

The purpose of this study was to evaluate statistically the quality control measurements that are made for the IMRT plans in prostate and H&N patients, before the beginning of the treatment, analysing their variations, the percentage of rejected and repeated measurements, the average, standard deviations and the proportion relations.

Methodology:

This is a retrospective study that includes all the quality controls of the IMRT plans produced between March and December of 2011 at the Hospital del Meixoeiro. The sample of this study is 141 quality control measurements, 52 referring to prostate cancer IMRT plans and the remaining 89 to H&N IMRT plans.

The equipment used in the IMRT quality controls was the MapCHECK® commercialized by SunNuclear Corporation®. This system contains diodes that detect the administrated dose, at the moment, by each planned treatment field, and this equipment only requires an annual calibration, as recommended by the manufacturer[6,8].

The commissioning of the planning systems consists in the comparison of the values measured at the linear accelerator with MapCHECK® and the calculated dose distribution[2-6,9-12]. These measurements allow an analysis of the planning through the graphical superposition of the measured and planned dose[3-11]. Each measurement is made with the gantry and the table with a rotation of 0º.

MapCHECK® uses the Gamma 3.3 (3%, 3mm) formula and takes into account the dose-difference and the distance-to-agreement (DTA)[3-6,9-12]. For areas with a low dose gradient the evaluated criteria is the dose-difference that corresponds to the difference between the measured dose and the planned dose, that can't exceed 3%. In the regions with high dose gradient it's applied the DTA in which there is evaluated the distance between the measured and the planned values that must be lower than 3mm. When these criteria are not respected the plans can't be approved. It's also evaluated the Gamma index, obtain by the following formula:

$$\gamma = min\sqrt{\frac{\Delta r^2}{\Delta dM} + \frac{\Delta D^2}{\Delta DM^2}} \leq 1$$

Where Δdm corresponds to DTA and ΔDM to dose-difference[9]

The obtained measurements are presented as relative dose and absolute dose. In the relative dose the treatment curve is superimposed to the planned curve only from a common point. The absolute dose compares all the measured points with all the planned points and, for that, is the most important result. The dose plans are rejected whenever the obtained values are lower than 95%, even if it's in a single field[13].

The results of this study where calculated by using frequencies and a proportion statistical test, with resource to the software SPSS® v.20.

Results:

The data recovered after the quality control of the IMRT plans for prostate and H&N patients are present in figure 1. From the 89 H&N plans evaluated 48 were approved in the first measurement, 32 were rejected and only 9 plans were repeated. Regarding the prostate patients, there were evaluated 52 plans, from which 28 were approved in the first measurement, 17 were rejected and 7 were repeated.

Figure 2 represents the rejected plans in prostate and H&N tumours associated with the rejection of the values of absolute dose and relative dose. In H&N rejected plans 10 were due to the measurements of the relative dose and 32 due to the absolute dose measurements. Regarding the prostate plans 3 were rejected due to the relative dose measurements and 17 due to the absolute dose measurements.

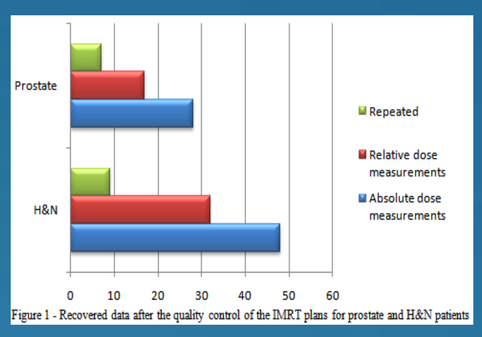

Figure 1 - Recovered data after the quality control of the IMRT plans for prostate and H&N patients

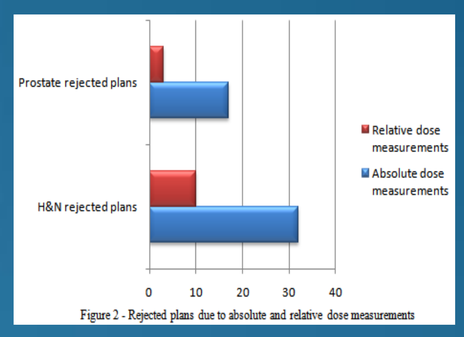

Figure 2 - Rejected plans due to absolute and relative dose measurements

In table 1 we can see the descriptive statistics of the obtained data regarding the quality control measurements of all the IMRT plans studied.

Table 1 - Descriptive statistics of the quality control measurements

	Sum	Mean	Std. Deviation
All plans	141,00	70,500	26,16295
Rejected plans	49,00	24,500	10,60660
Repeated plans	16,00	8,000	1,41421
Approved plans	76,00	38,000	14,14214

By applying an hypothesis test to evaluate the proportion relations the obtain results revel that the percentage of prostate and H&N approved plans is significantly inferior to 1 (p=0,53 and p=0,54, respectively). Using the mean and standard deviation values it was calculated the variation coefficient for all the plans. For the rejected plans this coefficient is 37,11%, for the repeated plans the coefficient is 43,29% and for the approved plans the variation coefficient is 37,22%.

Discussion/Conclusions:

All the IMRT treatments at Hospital do Meixoeiro are submitted to quality control measurements. Regarding the period taken into account in this study there were performed more IMRT treatment for H&N cancer than for prostate cancer. Although all rejected plans should be repeated we verified that only a few number of them are repeated.

Through the analysis of the data we observed that there is a high number of rejection in the first measurement, and that in both groups the values of the absolute dose were the motive for the rejection of the plans. There is a higher variation in the values of the rejected plans and a smaller variation in the values of the repeated plans.

There are some hypothesis that can explain the rejection of the plans: the lack of sensitivity of the treatment planning system to take into account the linear accelerator used; the fact that the beam segments are very small or with shapes that are very difficult to reproduce with the MLC; or because each beam segment has very few monitor units.

It's important to study the causes by each the plans are rejected in order to implement measures that improve the dosimetric studies and avoid a high level of rejected plans during the quality control.

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