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Strategies for quality assurance of intensity modulated radiation therapy

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Abstract. In late 2011 The Swedish Society of Radiation Physics formed a working group to concentrate on the Quality Assurance of modern radiation therapy techniques. The given task was to identify and summarise the different QA strategies in Sweden and also the international recommendations. This was used to formulate recommendations for practical guidelines within Sweden. In this paper a brief summary of the group’s work is presented. All the Swedish radiation therapy centres do a pre-treatment verification measurement as QA for every new IMRT and VMAT plan. Physicists do it and they believe it to be time-consuming. A general standpoint from all the centres was that new guidelines and legislation is needed to allow QA that does not require a measurement. Based on various international publications and recommendations the working group has presented two strategies, one where all new plans are checked through measurement and one where no measurement is needed. The measurement-based strategy is basically the same as the one used today with an extended machine QA part. The other presented strategy is process oriented where all the different parts of the treatment chain are checked separately. The final report can be found in Swedish on http://www.radiofysik.org.

1. Background and Purpose

The last few years have seen a rapid increase in the use of intensity modulated radiation therapy (IMRT) in Sweden. This trend is continuing with the implementation of rotational techniques such as VMAT (Volumetric Modulated Arc Therapy). Currently, the Quality Assurance (QA) of each treatment plan is regulated by the Swedish Radiation Safety Authority (SSM). The SSM’s regulations say that each field needs to be assured by measurement during the first fraction of treatment. For IMRT techniques this is not feasible and a pre-treatment verification measurement is done instead. This is very time-consuming, and considering the rapidly growing number of patients considered for IMRT a lot of resources are then required for the QA. The Swedish Society of Radiation Physics recognised a need for new guidelines and formed a national group to develop these. The group’s tasks were:

i) To survey how IMRT QA is done at the different radiotherapy clinics in Sweden.
ii) Review existing international recommendations on IMRT QA.
iii) To consider quality assurance concepts used by the industry.
iv) To develop practical guidelines for IMRT and VMAT QA.

The new guidelines in the resulting report didn’t specifically need to agree with the existing SSM regulations. The recommended guidelines can be found in the final report [11].

2. The survey
During the first quarter of 2012 a survey was sent out to the radiation therapy clinics in Sweden that were at that time performing IMRT/VMAT. Five clinics performed IMRT only, three only VMAT, while six clinics treated with both IMRT and VMAT. The average time spent on QA for two treatment plans was 65 min for IMRT and 43 min for VMAT including the preparations before measurement and evaluation afterwards.

One of the questions in the survey asked what changes were desired if there was no need to consider the legislation. All clinics wanted to shorten the time spent on QA. The four most common suggestions for time efficient QA were:

i) In–vivo EPID dosimetry, where there is no need for a phantom
ii) Independent dose calculation
iii) Measurement for the more complex cases only (complexity index)
iv) More focused and frequent machine QA to reduce patient QA

3. Published reports and guidelines
The task group chose to study publications by well-established organisations or internationally recognised institutions that have written guidelines for IMRT/VMAT or Tomotherapy. The studied publications are listed as references below.

All publications agree that some kind of patient specific QA is needed. The task group have chosen the following recommendations as support for the guidelines below.

i) A measurement is not necessary if an independent dose calculation is performed [1-3].
ii) The QA methods should be validated so they find the errors they are designed for [8, 9].
iii) The treatment plan integrity from approved status to treatment, must be verified [4, 9].
iv) Make sure the MLC, dose rate, collimator, and gantry angle parameters are well coordinated at all times [4].
v) One can use a complexity index to categorise treatment plans [5].

4. Suggested QA
The group have identified five parameters that need to be checked for every new treatment. MLC positions, Gantry angles, Dose/Monitor Unit, Data integrity and Dose calculation. These parameters is proposed to be assessed with two different strategies. The first, labelled measurement based QA, is the same as in use today where every plan is measured before treatment. The other strategy, labelled process oriented QA, is concerned with the control of each individual parameter affecting the treatment. The machine parameters such as MLC positions, Gantry angle and Dose/MU, are checked by an extended accelerator QA. The dose calculation and data integrity also needs to be checked for every plan. Process oriented QA is only recommended for standard (or ‘routine’) plans where the clinic has great experience and confidence in their delivery. The two strategies are illustrated in the flow chart below.

To implement the process oriented strategy a lot of work needs to be done on verification. All parameter controls must be verified and evaluated. Another challenge is the categorisation of the treatment plans. The non-standard plans needs to be identified so that they can be measured (see flow chart). This can be done using a complexity index. The index should be a measure of the plan’s
deliverability and every clinic should validate the index for their patient groups. Another way to regulate the plan complexity is to have strict treatment planning instructions and objectives. Currently, using a purely process oriented strategy is not allowed in Sweden, because of the SSM legislation. In any case, the group once again wants to stress the importance of validation of the QA-methods no matter what method is chosen, so that your method of choice actually reveals the errors you aim to discover.
5. References
[1] ESTRO Booklet no. 9: Guidelines for the verification of IMRT. Brussels, Belgium. ESTRO 2008