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SPECIFICATION OF VOLUME AND DOSE IN RADIOTHERAPY

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Abstract

As a result of a questionnaire about dose and volume specifications in radiotherapy in the Nordic countries, a group has been set up to propose common recommendations for these countries. The proposal is partly based on ICRU 50, but with major extensions. These extensions fall into three areas: patient geometry, treatment geometry, and dose specifications. For patient geometry and set-up one need alignment markings and anatomical reference points, the latter can be divided into internal and external reference points. These points are necessary to get relationships between coordinate systems related to patient and to treatment unit. For treatment geometry the main volume will be an anatomical target volume which just encompass the clinical target volume with all its variations and movements. This anatomical volume are the most suitable volume for prescription, optimization and reporting dose. A set-up margin should be added to the beam periphery in beams-eye-view to get the minimum size and shape of the beam. For dose specification the most important parameter for homogenious dose distributions is the arithmetic mean of dose to the anatomical target volume together with its standard deviation. In addition the dose to the ICRU reference point should be reported for intercomparison, together with minimum and maximum doses or dose volume histograms for the anatomical target volume.

1. INTRODUCTION

A questionnaire to all Nordic radiotherapy centres in 1991 about volume and dose specification [1] revealed several problem areas for specification of volumes and doses. The investigation resulted in setting up a group of radiotherapists and physicists under Nordic Association of Clinical Physics (NACP) to make consistent recommendations for volume/dose definitions and specifications.

The recommendations treat the situation at clinics with state of the art equipment and procedures, having the fairly uniform situation in the Nordic countries in mind. The proposals have evolved in discussions among radiotherapists and physicists in the Nordic countries during the last five years. They have also been considerably influenced by discussions with, and work of the international radiotherapy community (e.g. ICRU 50 [2]).

2. AIM

The recommendations should describe the fundamental concepts and quantities used during the whole radiotherapy chain to avoid misunderstandings between different personnel groups sharing the responsibility during the therapy process, but also between different

therapy centers reporting results. Ideally one should have a complete 3D description of patient and treatment volumes for every patient and a perfect fixation of the patient relative to the beam. In practice this is not the situation, but one should be aware of consequences for the limitations, simplifications and assumptions of the procedures used. Definitions and specifications have to fit the ideal situation as well as simpler cases, but if necessary special assumptions may be done for the 0simpler cases.

3. PATIENT GEOMETRY AND SET-UP

Since no rigid connection exists between different tissues and organs of the patient and the radiation beam, local coordinate systems have to be used. These systems are related to either patient or treatment unit. To get a connection between these systems two sets (internal and external) of Anatomical Reference Points have to be used. In addition Aligment Markings have to be used for correct set-up of the patient.

Internal Reference Points are local points inside the body and used for beam set-up at the simulator and portal verification at treatment unit. External Reference Points are palpable or visible points located on the surface of the body or on fixation devices that fit closely to the exterior of the body, and used for beam set-up both at simulator and treatment unit. A special case of External Reference Points are External Reference Systems, which are fixation systems like stereotactic frames in which the target volume is described and defined.

The Anatomical Reference Points should be as rigid as possible relative to patient and target tissues and located as close as possible to target tissues. Different means are developed to minimize set-up errors, and combined with the use of Anatomical Reference Points these will minimize errors between local coordinate systems and margins for volumes to be delineated. The use of Anatomical Reference points makes it possible to distinguish between variations inside the patient and external variations and errors for set-up of patient and beam.

4. TREATMENT GEOMETRY AND BEAM SET-UP

It is in many situations practical to distinguish between tumors/tissues as medical specifications and volumes as geometrical specifications, hence nomenclature should make this possible. Margins have to be added for different volumes to take into account variations inside the patient and variations/errors during set-up using the Anatomical Reference Points. In addition one should have just one type of target volume to avoid ambiguity. ICRU 50 [2] are using two different target volumes (Clinical and Planning Target Volumes (CTV, PTV)). We recommend to use an Anatomical Target Volume that just encompass the target tissues (CTV) with presumed variations and movements. This volume should be used for optimization and portal verification. A Set-up Margin should be added to the beam periphery in beams-eye-view to account for errors and variations of patient and beam set-up. Using this concept of splitting the margins into two part, one related to internal variations and one related to external variations, there will be no need for the Planning Target Volume. Due to this the nomenclature should be slightly different from ICRU50, se table I.

TABLE I. RELATIONSHIPS BETWEEN DIFFERENT TISSUES AND VOLUMES FOR TREATMENT GEOMETRY AND BEAM SET-UP

Tissue / Volume	Coord. system	Concept
Gross Tumor (ICRU 50 [2])	tumor coord. system	medical
+Microscopic Disease (verified/presumed)	tumor coord. system	medical
=Target Tissues (Clinical Target Volume)	tumor coord. system	medical
+Target Margin (3D)	patient coord. system	geometrical
=Anatomical Target Volume	patient coord. system	geometrical
+Set-up Margin (2D in beams-eye-view)	beam coord. system	geometrical

Target Tissues contains all Gross Tumor and verified or presumed Microscopic Disease to be treated, and are similar to Clinical Target Volume (ICRU50). Target Margin accounts for uncertainty in anatomic information, expected movements and/or variations of shape and size of Target Tissues relative to Anatomical Reference Points. Anatomical Target Volume is then a geometrically volume fixed to Anatomic Reference Points. The Target Tissues are expected to move just inside this volume, and therefore it should be used for prescription, optimization and reporting of doses. When there is no ambiguity between Anatomical Target Volume and other definitions of target volumes (e.g. CTV, PTV), Anatomical Target Volume can simply be called Target Volume. The radiation oncologist is responsible for delineating Target Volume.

The Set-up Margin (including uncertainties of positioning, movements during irradiation, dose planning, treatment technique and treatment unit performance charisteristics) have to be added to the periphery of the beam to give the final size and shape of beam. This should to be done in beams-eye-view projection and related to Anatomical Reference Points. No volume delineation (like ICRU Planning Target Volume) is then necessary for beam set-up.

The components of Anatomical Target Volume defined above will vary considerably. For postoperative treatment the Gross Tumor will normally be removed, and for brachytherapy the Target Margin will not be needed. In many cases Gross Tumor will be given a larger dose than Microscopic Disease, and Gross Tumor have to be delineated as a separate Target Volume with its own Target Margin. Organs at risk should similarly to Target Tissues have margins to delineate Organ at Risk Volumes.

5. DOSE SPECIFICATIONS

For homogenious dose distributions, as for most external radiotherapy situations, the arithmetic mean dose to Anatimcal Target Volume is the most important dose concept together with its standard deviation. Hence the arithmetic mean dose should be used for both prescription and reporting. For simpler cases, e.g. palliative treatments and single beam technique, the mean dose can be approximated by the dose around a representative point selected to be close to the average dose value. The arithmetic mean dose (or its approximated point dose) will normally be slightly different from the ICRU reference point dose, and for intercomparison purposes both should be reported.

For situations where dose distribution to Target Volume have large variations, e.g. brachytherapy and external therapy to very small volumes, a dose close to the minimum dose inside the volume will be the most important value and should be used for prescribing and reporting.

Minimum and maximum doses to Anatomical Target Volume should be specified if variations are larger than allowed tolerance range, together with dose to eventually hot spots outside Anatomical Target Volume. As a general rule all information available and used for dose specification (e.g. radiation and beam set-up parameters, dose plans, dose volume histograms) should be stored together with already mentioned dose values.

6. CONCLUSIONS

These recommendations will be discussed September 1995 at a Nordic Concensus Meeting in Umeå, Sweden.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, An Inventory of Dose Specification in the Nordic Centre and a Suggestion for a Standardized Procedure, IAEA TECDOC-734:83-89 (1994)

[2] INTERNATIONAL COMISSION ON RADIATION UNITS AND MEASUREMENTS, Prescribing, Recording, and Reporting Photon Beam Therapy, ICRU Report 50, Bethesda (1993)