ICRU Report 62: Prescribing, Recording and Reporting Photon Beam Therapy  
(Supplement to ICRU Report 50)

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Introduction

The present report, which appeared in November 1999, is a Supplement to ICRU Report 50, *Prescribing, Recording and Reporting Photon Beam Therapy*, published in 1993. Report 50 contained recommendations on how to report a treatment in external photon beam therapy. These recommendations were formulated in such a way that they can generally be followed in all centers worldwide.

Publication of Report 50 and its application to clinical situations stimulated broad interest, raised new questions, and sometimes triggered vigorous discussions and debates.

In the intervening years since Report 50 was published, irradiation techniques have advanced with many new procedures introduced. Driving this process are the considerable improvements in three-dimensional imaging which allow exquisite definition of target volumes, volumes of interest, as well as organs at risk. Naturally, treatment planning systems kept pace with these advances allowing improved radiation prescriptions.

For these reasons, the ICRU decided to publish a supplementary document in order to formulate more accurately some of definitions and concepts and to take into account the consequences of the technical and clinical progress. This new report complements the recommendations contained in the previous one and reflects their development.

When delivering a radiation treatment, the volumes and the doses must be specified for several purposes: prescribing, recording, and reporting. It is not the goal nor the task of the ICRU to recommend treatment techniques and absorbed dose levels. *Prescription* of a treatment is the responsibility of the radiation-oncology team in charge of the patient. *For reporting purposes*, it is important that clear, well defined, unambiguous, and universally accepted concepts and terminology are used to ensure a common understanding. Only under these conditions can a fruitful exchange of information between different centers be achieved.
Serving on the Report Committee responsible for the preparation of ICRU Report 62 were the following:


Volumes and Margins

The development of conformal therapy and the expected therapeutic gain, as well as the increased risk of missing some of the cancer cells, require a more accurate definition of the marginal around the target volumes. The concepts of Gross Tumor Volume (GTV) and Clinical Target Volume (CTV) do not need to be reconsidered, since they are pure oncological concepts independent of any technical development. However, Figure 1 illustrates some possible difficulties.

**Fig. 1**: Example of difficulty and risk of disagreement when delineating the Gross Tumor Volume. Schematic drawings on lateral radiographs for two patients with brain tumors, where the Gross Tumor Volume was delineated by:

- 8 radiation oncologists (----),
- 2 radiodiagnosticians (.........),
- 2 neurosurgeons (- - - -).

Adapted from Leunens et al., 1993.

The different factors to be taken into account when delineating the Planning
Target Volume (PTV) and the corresponding margins deserve accurate identification. In the present Supplement, the Internal Margin (IM) is defined so as to take into account variations in size, shape, and position of the CTV in relation to anatomical reference points (e.g., filling of stomach or bladder, movements due to respiration, etc.). The Set-up Margin (SM) is added to take into account uncertainties in patient-beam positioning.

Segregating the Internal Margin and the Set-up Margin reflects the differences in the source of uncertainties. The Internal Margin is due mainly to physiologic variations that are difficult or impossible to control (Table I). In contrast, the Set-up Margin is added because of uncertainties related mainly to technical factors that can be reduced by more accurate set up and immobilization of the patient, as well as improved mechanical stability of the machine.

The global concept and definition of the PTV as given in Report 50 is not changed. For each volume defined, a color code is proposed to assure clarity of interpretation.

Probability of Benefit Versus Risk of Complications

The Supplement to ICRU Report 50 recognizes that the linear addition of the margins for all types of uncertainties would generally lead to an excessively large PTV. This could result in exceeding the patient tolerance and fail to reflect the actual clinical consequences.

The risk of missing part of the cancer cell population must be balanced against the reduction of the risk of severe and serious normal tissue complications. The balance between disease control and risk of complications often dictates acceptance of reduced probability of cure in order to avoid severe and serious treatment-related complications (Figure 2).

Therefore, the selection of a composite margin and the delineation of the border of the PTV involve a compromise that relies upon the experience and the judgment of the radiation-oncology team.

Table I: Range of movements (mm) of the CTV in relation to an internal fix-point (vertebral body) in 20 patients with lung cancer, studied fluoroscopically during normal respiration. (From Ekberg et al., 1998.)

<table>
<thead>
<tr>
<th></th>
<th>medio-lateral</th>
<th>cranio-caudal</th>
<th>dorso-ventral</th>
</tr>
</thead>
<tbody>
<tr>
<td>maximum movement</td>
<td>5</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>average movement</td>
<td>2.04</td>
<td>3.9</td>
<td>2.4</td>
</tr>
<tr>
<td>standard deviation</td>
<td>1.4</td>
<td>2.6</td>
<td>1.3</td>
</tr>
</tbody>
</table>
**Scenario A.**

A margin is added around the Gross Tumor Volume (GTV) to take into account potential "subclinical" invasion. The GTV and this margin define the Clinical Target Volume (CTV).

In external beam therapy, to ensure that all parts of the CTV receive the prescribed dose, additional safety margins for geometric variations and uncertainties must be considered.

An Internal Margin (IM) is added for the variations in position and/or shape and size of the CTV. This defines the Internal Target Volume.

A Set-up Margin is added to take into account all the variations/uncertainties in patient-beam positioning.

CTV + IM + SM define the Planning Target Volume (PTV) on which the selection of beam size and arrangement is based.

**Scenario B.**

The simple (linear) addition of all factors of geometric uncertainty, as indicated in scenario A, often leads to an excessively large PTV, which would be incompatible with the tolerance of the surrounding normal tissues.

In such instances, instead of adding linearly the Internal Margin and the Set Up Margin, a compromise has to be sought and a smaller PTV has to be accepted. However, when aiming at optimizing the width of the "global" safety margin, a quantitative approach (e.g., using the formalism) is only relevant if all uncertainties, and their sigma, are known, i.e., only, in practice, in a few sophisticated protocols.

**Scenario C.**

In the majority of the clinical situations, a "global" safety margin is adopted. In some cases, the presence of Organs at Risk dramatically reduces the width of the acceptable safety margin (e.g., presence of the spinal cord, optical nerve, etc.). In other situations, larger safety margins may be accepted.
Since the incidence of subclinical invasion may decrease with distance from the GTV, a reduction of the margin for subclinical invasion may still be compatible with chance for cure, albeit at a lower probability rate.

It is important to stress that the thickness of the different safety margins may vary with the angle from which one looks at the PTV (e.g., bony structures or fibrotic tissue may prevent, at least temporarily, malignant cell dissemination).

(Note that if an adequate dose cannot be given to the whole GTV, the whole aim of therapy shifts from radical to palliative).

Organs at Risk

The compromise to be accepted when delineating the PTV is due to the presence of Organs at Risk. Such Organs at Risk are normal tissues whose radiation sensitivity and location in the vicinity of the CTV may significantly influence treatment planning and/or absorbed dose level. The problems resulting from the presence of Organs at Risk is discussed in more detail in the Supplement to Report 50.

The system of classifying Organs at Risk as "serial", "parallel", or "serial-parallel" is discussed, and the use of this system to interpret tolerance of various Organs at Risk is explained (Figure 3). A typical example of a tissue with a high "relative seriality" is the spinal cord, implying that a dose above the tolerance limit, even to a small volume, can totally impair the function of the organ (myelitis). In contrast, the lung has a low "relative seriality", implying that the main parameter for impairing pulmonary function is the proportion of the organ that receives a dose above the tolerance level. The heart can be considered as having a combined "serial" (coronary arteries) and "parallel" (myocardium) structure.

Planning Organs at Risk Volumes (PRV)

ICRU Report 62 stresses the fact that for the Organs at Risk, as for the CTV, movements and changes in shape and/or size, as well as the set-up uncertainties, must be considered. A margin must be added to compensate for these variations and uncertainties, which leads to the concept of the Planning Organ at Risk Volume (PRV). Thus, for the Organs at Risk, the PRV is analogous to the PTV for the Clinical Target Volume. For reporting, the description of the PRV (like that of the PTV) should include the size of the margins in all directions. The PTV and the PRV may overlap, and often do so, which implies searching for a compromise as discussed above.
Fig. 3: Schematic examples of tissue organization structures in the parallel-serial model.

- a serial string of subunits (e.g., the spinal cord),
- a parallel string of subunits (e.g., the lungs),
- a serial-parallel string of subunits (e.g., the heart),
- a combination of parallel and serial structures (e.g., a nephron).


Conformity Index

The concept of a Conformity Index (CI) is introduced and defined as the quotient of the Treated Volume and the volume of the PTV. This definition of the CI implies that the Treated Volume totally encompasses the PTV. Note that the Treated Volume is the tissue volume that receives at least the dose selected and specified by the radiation oncology team as being appropriate to achieve the purpose of the treatment, tumor eradication or palliation.

Not surprisingly, optimization of the CI may result in deterioration of other desired parameters, such as the size of the Irradiated Volume or the absorbed dose homogeneity in the PTV. Again, to optimize the CI, some overall compromises may be required.

Dose Specification for Reporting

Recommendations contained in Report 50 for dose specification for reporting are maintained in ICRU Report 62. First, the absorbed dose at the ICRU Reference Point should be reported. Then, the best estimates of the maximum and the minimum doses to the PTV should be reported. Furthermore, any additional relevant information should be given, when available, e.g., Dose-Volume-Histograms (DVHs). The absorbed doses to the Organs at Risk should also be given.

Reporting Doses in a Series of Patients

ICRU Report 50 dealt with dose reporting in an individual patient. Different issues are encountered when reporting treatments for a series of patients.
First, the treatment prescription or protocol should be described in detail, including the volumes, absorbed dose levels, and fractionation. The treatments should be reported following the above recommendations, and the deviations from the prescription should be stated. In particular, the proportion of patients in whom the dose variation is less than ±5%, ±5-10%, and more than ±10% of the prescribed dose at the ICRU Reference Point should be reported (Figure 4).

Fig. 4: Graph showing the proportion of a series of patients receiving an absorbed dose within three defined deviations from the prescribed dose in the protocol (< ±5%, ±5-10% and > ±10%).

The figure illustrates that most of the patients receive doses at the ICRU reference points close to the prescribed dose (less than 5% deviation in 81.6% of the patients). In contrast, large variations exist as far as the minimum dose in the PTV is concerned.

Upper: dose at ICRU point. Lower: minimum dose to the PTV.

(Courtesy of Ann-Margret Engström, RN, Oncological Center, Lund, Sweden).

When reporting the treatments in scientific journals, it is recommended that the prescribed CTV and PTV and corresponding doses be illustrated in an isodose distribution chart, giving the total absorbed doses in Gy.

The Three Levels of Dose Evaluation for Reporting

The level of completeness and accuracy of reporting therapeutic irradiation depends to a large extent on the situation in the department and on the aim of the treatment. Different levels of ambition for dose evaluation can be identified for different clinical situations. Three levels have been selected for reasons given below, but it is recognized that intermediate levels could also be identified.
In the following paragraphs, only the basic minimal requirements are outlined. However, as a general rule, reporting of any additional available information considered to be clinically relevant is recommended.

Since the publication in 1993 of the ICRU Report 50, some experimental techniques have been fully implemented and have become available as commercial software and equipment. Hence, the description of the three levels had to change accordingly. This is reflected in the definitions of the three reporting levels in ICRU Report 62.

**Level 1**

The requirements should be followed in all centers, for all patients. They constitute the minimum standard below which safe and accurate radiotherapy cannot be performed.

At this level, it is assumed that the dose at the ICRU reference point can be accurately determined as well as an estimate of the maximum and minimum dose to the PTV, using at least central axis depth dose tables and standard isodose charts.

These basic level requirements imply that medical and physical expertise as well as appropriate equipment are available.

**Level 2**

The standards of dose planning at this level allow the exchange of more complete and relevant information between different centers.

At this level, it is assumed that the GTV, CTV, OR, PTV, and PRV can be defined using reliable patient data acquisition tools and/or modern imaging techniques under reliable conditions (e.g., a series of CT and/or MRI sections). It is also assumed that complete dose distributions are available in planes or volumes, with inhomogeneity corrections, when appropriate. There must be a full quality assurance programme covering the whole procedure.

**Level 3**

Level 3 includes the development of new techniques for which reporting criteria are not yet established (e.g., BNCT, intensity modulation, etc.). Some procedures, which are now at level 3, can become level 2 with the development of techniques, equipment and standards.

At any level, the dose at the ICRU Reference Point and the best estimation of the maximum and the minimum dose to the PTV should be reported.
Reporting Exposure of Organs at Risk

To be able to calculate the probability of late effects in normal tissues, one must consider not only dose and fractionation, but also volumes of the Organ at Risk irradiated.

For each Organ at Risk, when part of the organ or the whole organ are irradiated above the accepted tolerance level, the maximum dose should be reported as defined in ICRU Report 50, Section 2.4.3. (Level 1). Examples: maximum spinal cord dose 42 Gy, 10 cm C1-C4, or left kidney dose 21 Gy, whole kidney.

The volume receiving more than the accepted tolerance dose should be evaluated from dose-volume histogram (Level 2 and above).

Clinical Examples

Finally, the Supplement to ICRU Report 50 contains an Appendix with three examples illustrating how the recommendations can be applied in typical clinical situations. The first example compares the irradiation of the internal mammary chain using a single electron beam or a combination of an electron beam and a photon beam. The second example deals with irradiation of prostatic adenocarcinoma. The third example illustrates how to report an irradiation of a bronchus carcinoma.

Conclusions

The Supplement to ICRU Report 50 provides updated recommendations that include the many advances in treatment techniques, treatment planning, and image based target definition that have become available. To assist the necessary decision process in therapy, the concept of "Conformity Index" is defined and introduced. Finally, clear guidance is provided for reporting treatments of individuals and series of patients. Hence, the Supplement will guide and assist the process of modern radiation therapy.

References

