

Prescribing, Recording, and Reporting Photon-Beam Intensity-Modulated Radiation Therapy

ICRU Report 83

ISBN: 978-1-5108-8924-8

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Published by Sage Publications USA

Copyright© (2010) by International Commission on Radiation Units and Measurements (ICRU)
All rights reserved.

ISBN (Print) 978-1-5108-8924-8

Printed by Curran Associates, Inc. (2019)

For permission requests, please contact sagepub.com/journals-permissions

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2633
Email: curran@proceedings.com
Web: www.proceedings.com

Prescribing, Recording, and Reporting Photon-Beam Intensity-Modulated Radiation Therapy (IMRT)

Contents

| | |
|--|-----------|
| Preface..... | 1 |
| Abstract | 3 |
| Executive Summary | 5 |
| 1 Introduction | 7 |
| 1.1 Overview of Intensity-Modulated Radiation Therapy (IMRT) | 7 |
| 1.1.1 From Three-Dimensional Conformal (3D-CRT) to Intensity-Modulated Radiation Therapy | 8 |
| 1.1.2 Delivery of IMRT..... | 8 |
| 1.1.3 Clinical Experience with IMRT | 9 |
| 1.2 Issues Common to Both 3D-CRT and IMRT | 11 |
| 1.2.1 Imaging and 4D Adaptive Treatment | 11 |
| 1.2.2 Margins and Uncertainties | 13 |
| 1.2.3 Radiation-Induced Secondary Cancers | 14 |
| 1.3 Aim of the Present Report and Relation to Existing ICRU Reports | 15 |
| 2 Optimized Treatment Planning For IMRT..... | 17 |
| 2.1 Introduction | 17 |
| 2.2 Comparison of 3D-Conformal and IMRT Treatment Planning..... | 17 |
| 2.3 Overview of the Optimization Process | 18 |
| 2.4 Examples of an Objective Function and the Iterative Optimization Process | 20 |
| 2.5 Iterative Search for an Improved Absorbed-Dose Distribution..... | 22 |
| 2.6 Beamlet Optimization and Aperture-Based Optimization | 24 |
| 2.7 Optimization Incorporating Biological Information | 25 |
| 3 Special Considerations Regarding Absorbed-Dose and Dose–Volume Prescribing and Reporting in IMRT..... | 27 |
| 3.1 The ICRU Reference Point and ICRU Reference Dose | 27 |
| 3.1.1 Conventional Reporting of Point Absorbed Doses | 27 |
| 3.1.2 Dose–Volume Calculations | 28 |
| 3.2 Level 2 Prescribing and Reporting For IMRT..... | 28 |
| 3.3 Impact of Modern Treatment-Planning Techniques..... | 30 |
| 3.4 Dose–Volume Reporting Specific to the OAR and PRV | 33 |
| 3.5 Reporting of Treatment Fields Delivered per Fraction | 34 |
| 3.6 Reporting of Software Versions for Treatment Planning and Delivery | 34 |
| 3.7 Level 3 Reporting: Reporting Developmental Techniques and Concepts..... | 34 |

PRESCRIBING, RECORDING, AND REPORTING PHOTON-BEAM IMRT

| | |
|---|-----------|
| 3.7.1 Dose Homogeneity and Dose Conformity | 34 |
| 3.7.2 Clinical and Biological Evaluation Metrics | 36 |
| 3.7.3 Equivalent Uniform Dose | 38 |
| 3.8 Reporting of Confidence Intervals | 38 |
| 4 Definition of Volumes | 41 |
| 4.1 Introduction | 41 |
| 4.2 Gross Tumor Volume (GTV) | 42 |
| 4.3 Clinical Target Volume (CTV) | 44 |
| 4.4 Internal Target Volume (ITV) | 46 |
| 4.5 Planning Target Volume (PTV) | 46 |
| 4.6 Organ at Risk (OAR) | 49 |
| 4.7 Planning Organ at Risk Volume (PRV) | 52 |
| 4.8 Treated Volume (TV) | 53 |
| 4.9 Remaining Volume at Risk (RVR) | 53 |
| 5 Planning Aims, Prescription, and Technical Data | 55 |
| 5.1 Introduction | 55 |
| 5.2 Planning Aims | 55 |
| 5.3 Special Situations Illustrating the Use of Planning Aims | 56 |
| 5.3.1 Dose Planning in the Buildup Region and in a PTV Extending Outside the Body Contour | 56 |
| 5.3.2 Overlapping Volumes and Conflicting Planning Aims | 57 |
| 5.3.3 Unexpected High Dose to the RVR | 58 |
| 5.4 Treatment Plan | 58 |
| 5.4.1 Prescription | 58 |
| 5.4.2 Technical Data | 58 |
| Appendix A: Physical Aspects of IMRT | 61 |
| A1 Absorbed-Dose Computation | 61 |
| A.1.1 Photon Interactions and the Energy-Deposition Processes | 61 |
| A.1.2 Modeling the Beam | 63 |
| A.1.3 Dose-Calculation Algorithms | 63 |
| A.1.4 Calculation of Absorbed Dose per Monitor Unit | 66 |
| A.2 Commissioning and Quality Assurance | 68 |
| A.2.1 Commissioning of Treatment-Planning Systems | 68 |
| A.2.2 Quality Assurance of IMRT Delivery Systems | 69 |
| A.2.2.1 Conventional-MLC Delivery Systems | 69 |
| A.2.2.2 Binary MLC Delivery Systems | 73 |
| A.2.3 Patient-Specific Quality Assurance | 75 |
| A.2.3.1 Measurements of Intensity from Individual Beams | 76 |
| A.2.3.2 Measurements of Absorbed Dose in Phantoms | 76 |
| A.2.3.3 Independent Absorbed-Dose Calculations | 77 |
| A.2.3.4 In-Vivo Dosimetry | 78 |
| A.2.3.5 Recommendations for Accuracy of Absorbed-Dose Delivery | 79 |
| Appendix B: Clinical Examples | 83 |
| B.1 Case Number B1. Squamous-Cell Carcinoma of the Supra-Glottic Larynx | 83 |
| B.1.1 Clinical Situation | 83 |
| B.1.2 Treatment Intent | 83 |
| B.1.3 Patient Positioning and Image Acquisition | 83 |
| B.1.4 Target Volumes | 84 |
| B.1.4.1 Gross Tumor Volume | 84 |

TABLE OF CONTENTS

| | |
|--|-----------|
| B.1.4.2 Clinical Target Volume | 84 |
| B.1.4.3 Planning Target Volume | 84 |
| B.1.4.4 Organs at Risk and Planning Organ-at-Risk Volume..... | 84 |
| B.1.5 Planning Aim | 85 |
| B.1.6 Treatment-Planning System and Treatment Unit..... | 85 |
| B.1.7 Prescription | 85 |
| B.1.8 Quality Assurance | 86 |
| B.1.9 Dose Reporting..... | 87 |
| B.2 Case Number B2. Squamous-Cell Carcinoma of the Lung | 87 |
| B.2.1 Clinical Situation..... | 87 |
| B.2.2 Treatment Intent | 87 |
| B.2.3 Patient Positioning and Image Acquisition..... | 87 |
| B.2.4 Target Volumes | 88 |
| B.2.4.1 Gross Tumor Volume | 88 |
| B.2.4.2 Clinical Target Volume | 88 |
| B.2.4.3 Planning Target Volume | 88 |
| B.2.4.4 Organs at Risk and Planning Organ-at-Risk Volume..... | 88 |
| B.2.5 Planning Aim | 89 |
| B.2.6 Treatment-Planning System and Treatment Unit..... | 89 |
| B.2.7 Prescription | 90 |
| B.2.8 Quality Assurance | 90 |
| B.2.9 Dose Reporting and Plan Evaluation | 91 |
| B.3 Case Number B3. Adenocarcinoma of the Prostate..... | 91 |
| B.3.1 Clinical Situation..... | 91 |
| B.3.2 Treatment Intent | 91 |
| B.3.3 Patient Positioning and Image Acquisition..... | 91 |
| B.3.4 Target Volumes | 91 |
| B.3.4.1 GrossTumor Volume..... | 91 |
| B.3.4.2 Clinical Target Volume | 91 |
| B.3.4.3 Planning Target Volume | 91 |
| B.3.4.4 Organs at Risk and Planning Organ-at-Risk Volume..... | 91 |
| B.3.5 Planning Aim | 91 |
| B.3.6 Treatment-Planning System and Treatment Unit..... | 91 |
| B.3.7 Prescription | 92 |
| B.3.8 Quality Assurance | 92 |
| B.3.9 Dose Reporting..... | 92 |
| References..... | 93 |