



CURRICULUM OUTLINE FOR TRANSITIONING FROM 2-D RT TO 3-D CRT AND IMRT

Purpose

The purpose of this curriculum outline is to provide a framework for multidisciplinary training for radiation oncologists, medical physicists and radiation therapy technologists (RTT) (radiation therapists and radiographers; for these outlines dosimetrists will be included in the RTT category) so that they are aware of the infrastructure and the changes needed for implementing 3-D Conformal Radiation Therapy (CRT) and/or intensity modulated radiation therapy (IMRT) effectively and safely. The total curriculum is comprehensive and is intended as a guide for setting up training programmes, either in the form of short courses or hands-on training experiences in a clinical setting (e.g., fellowships). There will not be enough time to cover all the material in one short course. Therefore, the components most relevant for the attendees will have to be selected.

Specific Curriculum Objectives

1. To provide **instructional material** to allow effective and safe transitioning from 2-D Radiation Therapy (RT) to 3-D CRT to IMRT
2. To provide **instructional material to guide hands-on practical training** for specialized sub-disciplines or sub-topics in transitioning from 2-D RT to 3-D CRT to IMRT.
3. To provide **disease site-based learning** in transitioning from 2-D RT to 3-D CRT to IMRT.
4. To help develop **regional expertise** that will allow for the training of others in the region.

Assumptions

Ideally, course participants should consist of teams, from the same department, composed of a radiation oncologist, medical physicist and RTT who are involved in the implementation of 3-D CRT (and/or IMRT). The participants should be qualified staff working in a radiotherapy department with at least 3 years of radiation therapy-related clinical experience. Medical physicists are assumed to be knowledgeable about beam calibration procedures following IAEA-TRS-398 or other national calibration protocol and QA procedures for 2-D Radiation Therapy. Where non-ideal conditions exist, the course directors will have to judge the appropriate entry requirements. In such cases, the course content may have to be adjusted accordingly.

References

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- [3] IAEA. Specification and Acceptance Testing of Radiotherapy Treatment Planning Systems. IAEA-TECDOC-1540, IAEA, Vienna, 2007.
- [4] IAEA. Commissioning of Treatment Planning Systems: Testing for Typical External Beam Treatment Techniques. IAEA-TECDOC-1583, IAEA, Vienna, 2008.
- [5] IAEA. Mould Room Techniques for Teletherapy. IAEA Practical Radiation Technical Manual (IAEA-PRTM-4), IAEA, Vienna, 1999.
- [6] IAEA. Setting Up a Radiotherapy Programme: Clinical, Medical Physics, Radiation Protection and Safety Aspects. IAEA, Vienna, 2008.
- [7] Podgorsak, E.B. (Technical Editor). Radiation Oncology Physics: A Handbook for Teachers and Students. IAEA, Vienna, 2005.
- [8] IAEA, Applied Sciences of Oncology Distance Learning Course. IAEA, Vienna 2008.
- [9] IAEA. Absorbed Dose Determination in External Beam Radiotherapy. IAEA-TRS-398, IAEA, Vienna, 2000.

Training Curriculum for transitioning from 2-D RT to 3-D CRT and IMRT

The details of the contents, the order of the lectures, the hands-on activities, and the level of complexity should be adjusted depending on the knowledge level of the participants, the expertise of the lecturers, the hands-on resources available, and the length of time allocated for the training. Different components of the course will have special relevance to different professionals. Where shown, the training should be focused on the professionals indicated:

RO = Radiation Oncologist

MP = Medical Physicist

RTT = Radiation Therapy Technologist (Radiation Therapist, Radiographer, or Dosimetrist)

It should be emphasized that the details of the course or training structure remains to be determined by the course organizers. The full outlines shown below will be very difficult to implement in a single, short training course.

The learning environment should include:

- Lectures
- Demonstrations
- Reading of resource material
- Ample time throughout the course for open discussion
- Hands-on, practical exercises

TRAINING CURRICULUM FOR TRANSITIONING FROM 2-D RT TO 3-D CRT AND IMRT

1. Introduction [RO, MP, RTT]
 - a. Current situation & perspectives of radiation oncology in region/country of interest
 - ii. Clinical (common cancers and stage at presentation)
 - iii. Technical and human resource availability/competency
 - iv. Sustainability issues
2. Radiation therapy principles [RO, MP, RTT]
 - a. Clinical indications and outcomes
 - b. Applied radiobiology
3. Altered fractionation
 - a. Fractionation principles
 - i. The linear quadratic model
 - b. Fractionation
 - i. Standard
 - ii. Hyperfractionation
 - iii. Accelerated fractionation
 1. Pure
 2. Combined with hyperfractionation
 3. Combined with hypofractionation
4. Overall QA/Review [RO, MP, RTT]
 - a. Internal peer review
 - i. QA/chart rounds
 - ii. QA Committee
 - iii. Departmental meetings
 - b. Protocols
 - c. End-to-end testing
 - d. External protocol/dosimetry audit; external peer review
 - e. Outcome monitoring
5. Equipment selection, acceptance testing, commissioning, QA/QC [MP]
 - a. Immobilization
 - b. CT simulator
 - c. Treatment planning system (beam modelling and delivery)
 - d. Treatment machine
 - i. Linac
 - ii. MLC
 - iii. Delivery modes (static or dynamic)
 - iv. 3-D CRT or IMRT on a Cobalt unit
 - v. In-room imaging

- e. R & V
 - f. Dosimetry equipment
 - g. Data transfer standards (DICOM, DICOM RT)
 - h. Technology specific QC
 - i. Maintenance issues
6. Evolution of RT from 2-D to 3-D CRT to IMRT [RO, MP, RTT]
- a. Steps in the RT process
 - b. Description of differences from 2-D RT to 3-D CRT to IMRT
 - i. Milestones
 - ii. Staffing/training
 - iii. Appropriate patient selection (2-D RT to 3-D CRT to IMRT)
 - iv. Comprehensive QA
 - v. Changes to documentation for intention, imaging, prescribing, recording and reporting
7. Treatment delivery hardware/software for 3-D CRT [MP, RTT, RO]
- a. Beam shaping devices
 - i. Blocks, multileaf collimators (MLC)
 - b. Beam modifiers
 - i. Wedges
 - 1. Physical, dynamic
 - ii. Compensators
 - c. Small field dosimetry
8. Delivery Techniques for IMRT [RO, MP, RTT]
- a. MLC design, capabilities and limitations
 - b. Step and shoot
 - c. Dynamic MLC
 - d. Volumetric modulated arc
9. Evidence based medicine and new technology
- a. The need for EBM
 - b. Grading of evidence
 - c. Examples for the need for EBM
 - d. Terminology of study phases as applied to radiotherapy and give examples
 - e. Factors which influence EBM with examples
10. Patient setup and immobilisation [RO, MP, RTT]
- a. Principles of immobilisation for accurate set-up including special issues for IMRT
 - b. Immobilisation issues in the bore of a diagnostic CT
 - c. Brain/central nervous system (CNS) (with traditional and stereotactic methods)
 - d. Head & neck
 - e. Breast
 - f. Thorax (including frame based systems)

- g. Pelvis (including possibilities of alpha cradle and similar techniques)
- h. Frame-based body systems
- i. Other

11. Imaging for target volume and organ-at-risk (OAR) determination [RO, MP, RTT]

- a. Conventional fluoroscopic simulation
- b. CT simulation
 - i. Positioning (changes from 2-D RT to 3-D CRT to IMRT)
 - ii. CT imaging parameters (e.g., field of view, helical/axial, slice thickness, radiation parameters, slice spacing, contrast, 4-D, window/level and impact on outlining)
 - iii. Multiple CTs for re-planning
 - iv. Contrast
 - v. Data transfer
 - vi. Conversion of CT numbers to relative electron densities for dose calculations
 - vii. Prospective/retrospective gating
- c. Use of other modalities, e.g., MR, SPECT, PET, pre-chemo CT, etc.
 - i. Image fusion/registration
 - ii. Functional imaging

12. Definition of target volume and organs-at-risk (OAR) [RO, MP, RTT]

- a. ICRU 50, 62, 71, 83
- b. Model based segmentation
 - i. Automatic contouring of 3-D volumes based on a library of existing patients
- c. Dose prescription methods for IMRT
 - i. D_{\min} , D_{mean} , D_{\max}
 - ii. Dose-volume histogram (DVH) (frequency and cumulative)
 - iii. Dose-volume constraints
 - iv. D_x , V_y

13. Contouring and prescribing for specific clinical sites for IMRT [RO (less detail for MP and RTT)]

- a. Brain/central nervous system (CNS)
- b. Head & neck (including nodal anatomy)
- c. Breast
- d. Lung
- e. GU
- f. GI

14. Geometric uncertainties [RO, MP, RTT]

- a. Defining margins (GTV to CTV, CTV to ITV to PTV; OAR to PRV)
 - i. Microscopic extension and relationship to disease
 - ii. Geometric uncertainties
 - iii. Measuring geometric uncertainties
 - iv. Motion management and use of 4-D images

15. Treatment planning for 3-D CRT [RO, MP, RTT]

- a. From 2-D RT to 3-D CRT
- b. Beam directions
 - i. Isocentric vs SSD
 - ii. Non-coplanar
 - iii. Beam weighting
 - iv. Normalization
 - v. Field matching
- c. Virtual simulation, DRRs, DCRs
- d. Dose computation
 - i. Models
 - 1. Tissue inhomogeneity corrections
- e. Treatment optimization
 - i. Manual (e.g., forward)
 - ii. Automatic (simple versions as might be used for gantry angle determination)
- f. Independent verification
- g. Transfer to delivery system and/or record and verify system
- h. Treatment planning clinical examples for 2-D RT to 3-D CRT
 - i. In each case, compare 2-D RT to 3-D CRT
 - 1. Head & neck
 - 2. Lung
 - 3. Breast
 - 4. GU

16. Treatment planning for IMRT [RO, MP, RTT]

- a. From 3-D CRT to IMRT
- b. Inverse planning
- c. Beam directions
 - i. Isocentric vs SSD
 - ii. Non-coplanar
 - iii. Field matching
- d. Virtual simulation, DRRs, DCRs
- e. Dose computation
 - i. Models
 - 1. Tissue inhomogeneity corrections
- f. Treatment optimization
 - i. Manual (e.g., forward)
 - ii. Automatic (e.g., inverse) – weighting, cost function, additional contours to aid optimization
 - iii. Problems with skin dose in inverse planning
- g. Simultaneous integrated boost
- h. Independent verification
- i. Volumetric modulated arc techniques
- j. Transfer to delivery system and/or record and verify system

17. Plan evaluation for IMRT [MP, RTT, RO]

- a. D_{\min} , D_{mean} , D_{\max}
- b. Dose-volume histogram (DVH) (differential and cumulative)
- c. Dose-volume constraints

- d. D_x, V_y
- e. Radiobiological considerations including risk of second malignancies
- f. Tumour control probability (TCP), normal tissue complication probability (NTCP)
- g. Dose prescription methods for IMRT
- h. Documentation, recording and reporting

18. Additional physics equipment for IMRT [MP, RTT, RO]

- a. Beam shaping devices
 - i. Multileaf collimators (MLC)
- b. Beam modifiers
 - i. Wedges
 - 1. Physical, dynamic
 - ii. Compensators
- c. Dynamic MLC delivery
- d. Volumetric arc
- e. Dosimetric considerations for IMRT [MP]
 - i. Small field dosimetry
 - ii. Tongue and groove and leaf leakage
 - iii. Dynamic delivery issues
 - iv. Matching of opposing jaws
 - v. Fluence maps

19. Patient specific QA for IMRT [MP, less details for RO, RTT]

- a. Machine specific aspects (e.g., MLC alignment methods)
- b. Individual patient QA
- c. Relation between individual patient QA and routine machine QA
- d. Special equipment for QA

20. Treatment verification imaging/dosimetry [MP, RTT, RO]

- a. Port films
- b. Electronic portal imaging devices (EPID)
- c. Planar kilovoltage (kV) imaging
- d. Cone-beam CT (CBCT)
- e. Other image-guided radiation therapy (IGRT) techniques
- f. *In vivo* dosimetry

21. Special treatment techniques (as needed) [RO, MP, RTT]

- a. Total body irradiation (TBI); half body irradiation (HBI), total marrow irradiation (TMI), total lymphoid irradiation (TLI)
- b. Stereotactic radiosurgery (SRS), stereotactic radiotherapy (SRT), stereotactic body radiotherapy (SBRT)
- c. Cranio-spinal RT
- d. Paediatric RT
- e. Dose escalation
- f. Other

CLINICAL/PRACTICAL TEACHING AND LEARNING

In order to meet the outcome of effective and safe transitioning from 2-D RT to 3-D CRT and/or IMRT there will be an emphasis on practical teaching and learning for the achievement of clinical competence. The learning environment will therefore include demonstrations and hands-on practice under supervision, in the following:

- a. Immobilization and set-up [RTT]
- b. Planning image acquisition (e.g., CT scanning) [RTT]
- a. Image co-registration [RO,MP,RTT]
- c. Contouring [RO, MP, RTT]
- d. Planning [RO, MP, RTT]
 - i. Breast
 - ii. Head & neck
 - iii. Gynae
 - iv. GU
 - v. GI
 - vi. Brain/CNS
 - vii. Lung
- e. Data transfer [MP, RTT]
 - i. R & V
- f. Plan validation [MP]
 - i. Phantom study (specific machine and patient QA)
 1. Scan, plan, deliver, measure
- g. Documentation [MP, RTT, RO]
- h. Positioning verification [RTT]
- i. *In vitro/in vivo* dosimetry [MP, RTT]

ASSESSMENT FOR PARTICIPANTS

All participants will do an assessment.

There will be some variations according to the roles of each category.

The assessment will focus on the implementation of 3-D CRT and/or IMRT.

The assessment will take the format of a short written test to assess knowledge and one or two practical tasks to assess clinical skills.

TRAINING EVALUATION

The participants of any course/training will be asked to complete a survey to provide feedback on the course contents, the organization, and the lecturers and to identify areas for improvement.