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.
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. $D_{\text{min}}$, $D_{\text{mean}}$, $D_{\text{max}}$
   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 marguins (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. $D_{\text{min}}$, $D_{\text{mean}}$, $D_{\text{max}}$
   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]
c. Image co-registration [RO, MP, RTT]
d. Contouring [RO, MP, RTT]

e. 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.