Positioning and immobilisation requirements for IMRT techniques

Brent Chesson
Clinical Co-ordinator – Radiation Therapy services
Peter MacCallum Cancer Centre

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Aim

• Refresh understanding of how IMRT dose distributions differ from 2D and 3DCRT

• Understand how this impacts immobilisation requirements for IMRT techniques

• Consider options for immobilisation for a range of anatomical sites
  • Head & neck
  • Thorax
  • Abdo/pelvis
Specific Learning Objectives

• Understand the types of set-up errors in radiotherapy
• Understand the need for increased positional accuracy with IMRT treatments
• Understand the process of patient positioning
• Learn practical methods of immobilisation for common cancer sites
Introduction

To understand the need for effective positioning and immobilisation in IMRT techniques, some revision is required:

1. Goals of radiotherapy treatment
2. Types of cases treated with IMRT
3. How IMRT dose distributions are different from 2D and 3DCRT
Introduction

Goals of radiation therapy

– Precise delivery of high dose to the target

– Sparing dose to surrounding critical structures

– Limited dose to other surrounding healthy tissue
Introduction

Essential elements in achieving these goals:

– Appropriate patient positioning
– Adequate immobilisation
– Accurate delineation of target & structures
– Appropriate beam arrangement/ technique
– Accurate system of translating plan to patient
– Excellent quality assurance
– Adequate treatment verification
Introduction

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Case selection for IMRT

1. Nearby critical structures

- IMRT can help shape the dose distribution to avoid dose to nearby sensitive structures

- CAUTION: IMRT is not always necessary. A simple solution may still be possible.
Case selection for IMRT

Simple beam arrangement adequate
Case selection for IMRT

Multiple critical structures will require IMRT
Case selection for IMRT

Well suited to head & neck cases
Case selection for IMRT

2. Irregularly shaped target volumes

– Changing shape across the length of the target

– Concave shaped targets
Case selection for IMRT
Characteristics of IMRT dosimetry

- Reserved for complex cases
- Rapid fall off of dose surrounding the target
- Potentially very steep dose gradients near critical structures
- Positional errors have larger impacts!
  - Underdose the target
  - Overdose surrounding sensitive structures
Characteristics of IMRT dosimetry

– IMRT extends beyond producing a good plan in the planning system

– Must translate and be delivered accurately to the patient to ensure dose is delivered as planned

– IMMobilisation IS CRITICAL
Treatment accuracy

• Dosimetric accuracy/errors
  – Dealt with in other presentations

• Patient setup accuracy/errors
  – The focus of this presentation
Patient Setup Errors

- Discrepancy between planned and actual treatment position

- Two types of setup errors:
  - **Random Errors**: Inconsistent deviations
  - **Systematic Errors**: Consistent deviation
Patient Setup Errors

Random Errors:

– Inconsistent repositioning by RTT staff
– Patient movement after setup
– Variables in immobilisation devices
– Inconsistent interpretation of setup information (e.g. skin marks/palpation)
Patient Setup Errors

Systematic Positioning Errors:

– Are most commonly “Planning to Treatment” related errors:

• Change in patient positioning (e.g. different setup between CT & treatment)
• Incorrect translation of the isocentre to the patient setup
• Treatment plan transcription errors
Patient Setup Errors

- Important for any radiotherapy treatment

- Critical for IMRT treatments

- Must be accounted for by a robust planning processes to translate treatment plan to patient

- Requires a well documented patient setup and quality immobilisation of the patient
2D technique with opposing fields

PTV
Spinal cord
95% isodose line
IMRT technique

PTV
Spinal cord
95% isodose line
Minimising Patient setup Errors

Random

– Improved patient immobilisation
– Proper education of RTT staff
– Consistent, well documented set-up procedures

Systematic

– Detailed documentation for individual set-up
– Accurate translation of isocentre to patient
– Good work practices and systems of checking
Importance of patient positioning

Careful consideration of patient positioning at the CT scan will allow optimal treatment planning:

– Localise the relevant treatment area
– Comfortable/reproducible between CT & treatment sessions
– Immobilise patient during delivery
Importance of patient positioning

Important considerations:

• IMRT treatments will take longer due to imaging requirements, beam number & high MU’s

• Patient comfort is important!

• IMRT will likely involve more beam angles

• Consider clearance of beam angles
Importance of patient positioning

e.g. Limb sarcoma: Reposition contralateral leg
Principles of an accurate set-up

- Comfortable relaxed position
- Use basic stabilisation aids to improve patient comfort
Principles of an accurate set-up

• Align to the patient midline – reproducible

• Use modern laser system

• Extended surface markings superiorly & inferiorly
  – e.g. For abdominal setup, additional reference points should be used on the thorax & pelvis for accurate alignment.
Principles of an accurate set-up

• Reference all elements of the patient position
  – Distances between anatomical points
  – Positioning of extremities where relevant

• Make use of immobilisation devices
  – Carefully recorded and cross checked settings of any adjustable devices
CT scanning

- Patient alignment
- Lasers
- Fiducials
Importance of immobilisation

Immobilisation is critical:

- To ensure the same volume is treated each day
- To ensure that critical structures are excluded from the treated volume as planned
- To provide confidence that the PTV may be safely reduced without risking geographical miss
Principles of immobilisation

Immobilisation is essential to enable:

- Comfort
- Stability
- Precision
- Efficiency
Immobilisation devices

- Vary in construction from simple to highly complex.
- Made locally or by commercial vendors.
Immobilisation devices

Simple strategies used in 2D planning are not appropriate for the precision required for IMRT.
Generic body support devices:

Must be of appropriate size for patient, appropriately positioned and reproducible between CT and every treatment appointment.

One size does not fit all!
Immobilisation devices

Customisable neck supports a better solution
• Adaptable to individual neck contour
• Better control of head tilt
Immobilisation devices

Vacuum cushions:

- Customisable to body contour
- Maximise stability in treatment region
- Extend beyond treatment region to reproduce position
Compromise due to CT bore size

Conventional simulator
- kV arm distant from patient
- Little restriction in positioning

CT scanner
- Limited bore size limits positioning options
Wide bore CT scanners permit a wider range of treatment positions & tumours
Wide bore CT scanners permit a wider range of treatment positions & tumours.

SFOV: 50cm
RFOV: 50cm

SFOV: 70cm
RFOV: 90 cm
Key criteria of immobilisation devices

- Device is rigid and will maintain shape
- Patient comfortable and fully supported
- Patient movement well constrained
- Device conforms to patient’s external contours
- Able to be treated through
Key criteria of immobilisation devices

- Fits all imaging and treatment couchtops in your department (simulator, CT, MRI etc. and on the treatment unit)

- Surface dose will not be adversely affected

- Indexes to couchtops – reproduces patient position on the couch
Head & neck

• Aim of treatment:
  – Highest possible loco-regional control
  – Preservation of function
  – Good cosmetic result
  – Best quality of life outcome

• Early stage: Surgery or RT
• Late stage: Surgery + RT (in most patients)
Head & neck

Unsatisfactory for IMRT

- Tapes/chin straps
- Head rest alone
- Use generic shape neck supports with care
Head & neck

Satisfactory for IMRT

• Well fitting standard neck support

• Customisable neck support (preferable)
  – Vacbag
  – Expanding foam

• Must be used in combination with a mask
Masks - thermoplastic
– 3 Clamp; 4 Clamp; 5 Clamp - preferable
Head & neck

- Localize patient with appropriate neck extension – neutral, hypo-extension or hyper-extension of the neck position as relevant
Head & neck

Mouth bites
- Used to displace tongue
  - Contralateral side of mouth (unilateral techniques)
  - Depress (treating above hard palate)
Oncologist presence useful if RT’s inexperienced

Multiple hands to optimise fit
Key location points:

- Top of head
- Nasion
- Chin
- Sternal notch
Thorax

- IMRT used for:
  - Cord sparing
  - Reduce oesophageal dose
  - Reduce cardiac dose
  - Note – volume of low dose lung may increase
Thorax

Be mindful of:

– Interplay effects of dynamic MLC’s and a moving target

– Motion management strategy (e.g. 4DCT)
Thorax
Thorax
Thorax

Reference points on chest

– Anterior

– Laterally (rotation)

– Superior & inferior to target
Pelvis

- Standard of care for Ca Prostate
  - Rectum sparing
  - Dose escalation
    - 66Gy; 70Gy; 74Gy; 78Gy

- Ca Bladder
- Ca Anus
- Pelvic sarcoma
Pelvis

- Patient preparation
  - Minimise rectal filling
  - Bladder filling protocol
Pelvis

- Pre-treatment bladder scanner
- Reproduce bladder volume from CT
Pelvis

- Internal target motion
  - e.g. Bladder filling

- Implanted fiducial seeds for intact prostate
  - Daily image guidance
  - MV possible
  - kV preferable
Pelvis
Pelvis

- Knee positioning (height adjustable for comfort)
- Foot stocks (position & tilt adjustable)
- Indexed to treatment couch
Pelvis

Drapes

– Mark references and isocentre onto cast
– May be more time consuming to setup
– Pressure on a full bladder
Setting up for treatment

- Setup couch with required accessories
- Cross check settings on immobilisation devices
- Consider patient preparation (e.g. bladder filling etc).
- Position patient as per setup instructions
- Apply any additional positioning devices (e.g. mouth bite).
Setting up for treatment

• Clearly identify all reference points from setup instructions
• Measure distances between points and ensure these correlate with setup instruction from CT
• Align patient and room co-ordinate systems (superimpose orthogonal room lasers with skin marks)
• Set isocentre determined from computer plan (this should always be independently cross at planning and daily at treatment)
Setting up for treatment

- Apply any additional accessories (e.g. bolus)
- A final cross checking procedure of the entire setup and beam placement, including 2 RTT’s, should be considered mandatory.
- Image guidance should be considered the final check and process for minor adjustment
- Only treat when certain that the set-up is correct
Take home messages

• IMRT with associated highly conformal dose distributions require:
  – Rigid immobilisation
  – Accurate positioning and patient set-up
  – Restriction of systematic and random errors
  – Reproducible treatment delivery
Thank you for your time.