Immobilization and patient positioning

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PRECISION RADIOTHERAPY

- State of Art Equipment with MLC’s and microMLC’s
- Complex treatment techniques – 3DCRT, IMRT/IGRT, SRT/SRS
- Extensive use of Imaging Modalities – CT, MR, PET-CT
- Delineation of Volumes - protocols
- Networking environment
- Advanced Planning Systems- 3D, MC Algorithms
- Image guidance with KV or MV cone beam CT
- Electronic Portal Imaging (EPID) for verification
- Best possible Immobilization
Clinical Target Volumes

- **GTV - Gross Target Volume** includes tumor that can be seen in treatment planning images (typically CT, MR or PET).

- **CTV - Clinical Target Volume** includes the GTV plus regional lymph nodes and tissue adjacent to the GTV that may contain microscopic tumor cells. The CTV is what the physician wants to treat.

- **PTV - Planning Target Volume** includes CTV plus a margin of healthy tissue to account for inter- and intrafraction organ motion and set-up. In order to treat the CTV, the planner must design a treatment plan for the PTV.
Margins in high precision RT

- Geometric margin (PTV) depends upon: set up errors and organ motion.

- PTV = Internal Target volume (ITV) + Set up margin (SM)
- Internal target volume (ITV): CTV + Internal motion
- Set up margin (SM): margin for set up uncertainties

- ITV: reduced by organ motion tracking
- SM: reduced by more accurate immobilization

- PTV margin reduced by: accurate immobilization & organ motion tracking
CONFORMING THE PTV WITH MLC

Need of accurate Immobilization!
PITFALLS

As we move from standard treatment to conformal treatment

- Due to more accurate localization with above modalities, the field sizes (margins) have reduced considerably
- Further, due to MLC’s irregular shaped conformation became easily possible
- Volume delineation protocols defined different regions within the target and a differential dose to these is possible

This has made the Immobilization during day to day delivery very much important
Immobilization

Proper immobilization: basic but very important step for high precision RT

Types

- Plaster of Paris cast
- Thermoplastic shells
- Perspex shell
- Acrylic shell
- Stereotactic frame
- Vacuum bags
POSITIONING: Simple in-house devices

- Inform patient about immobilization
- Comfortable positioning
  1. **Knee Rest**- comfortable, relaxes back against flat couch
  2. **Ankle rest**- change in foot-change/rotation
     bony reference points
  3. **Belly board**- takes small bowel away from radiation field by gravity
  4. **Head rest-pillow**:- relaxes strain on neck, comfortable
POSITIONING

- Intention
  - comfortable
  - reproducible
- treatment delivered with optimal sparing of normal tissues
- Supine/prone (site specific)
- Head rest/knee rest /Breast board/rubber traction and other accessories (institution protocol)
- Arms above/below
- Documented in patient file
- Generally finalized in simulator/CT simulator
SUPINE POSITION

- Commonest position
- Easier, comfortable, easily reproducible
- Hands on chest, head on pillow, legs straight
- FROG leg position: - groin skin folds, low 1/3 vaginal tumours

Possible disadvantages of SUPINE POSTION

- Obese patient: - skin marks on ant skin-shift by several centimeters-poor reproducibility!
- Skin folds - more chances of skin reactions
- Straps, tapes can be used to decrease skin folds- variation/ slipping intra & interfracton!
- This causes variation in thickness-non uniform dose
POSITIONING
LATERAL AND PRONE

LATERAL – MID EAR

PRONE - MEDULOBlastoma
PRONE POSITIONING
RECTUM

**BELLY BOARD**

Principle: gravitation pulls small bowel into hollow cavity – bowel sparing

Pros and cons

I. Good abdominal muscle tone - less effective

II. Thin patients benefit equally as fat patients

III. In obese patients it’s the skin fold, fat – falls into hollow not small bowel!

IV. Compression roll under pelvis
BREAST POSITIONING

PERSPEX BREAST BOARD  THERMOCOL BOARD  LINAC BREAST BOARD
Plaster of PARIS Moulds

- (CaSo4)2.H2O
- POP Bandages as per size (6” wide)
- Vaseline the surface
- Use rubber Traction as appropriate
- Wrapped and positioned over face as per marking
- Use Aluminum wire at border/junction
- Moulds by itself when dried
- Simple, inexpensive, preliminary form of immobilization
PERSPEX & ACRYLIC MASKS

- POP negative mask
- Dental stone cast or bust is made from this
- Mix (paste) of acrylic powder and cold cure liquid is spread uniformly on the cast
- Acrylic shell thus formed is removed after appropriate time
- Alternatively the bust is used to form Perspex moulds with sheets of 2-3 mm using a vacuum forming machine
- Both these techniques are time consuming and are now almost replaced by thermoplastic
THERMOPLASTIC MASKS

- Thermoplastic sheets in various sizes & suitable for various sites
- The water bath maintaining ~70° C
- The sheets get malleable at this Temp.
- Wrapped over area of interest carefully
- Appropriate markers put during simulation
Thermoplastic mask and neck-rests

3-Clamp

4-Clamp

5-Clamp
Supports for immobilization of neck

Set up error varies with different head support

Natural position preferred in head and neck cancer
STEREOTACTIC IMMOBILIZATION

SPECIAL SRT THERMOPLASTIC MASK

SRS POSITIONING BOX
VACCCUM BODY BAG AND STEREOTACTIC BODY FRAME

Contains pre-expanded polystyrene micro-spheres

Upon vacuum they pull together tightly and bag/cushion becomes rigid, retaining shape of body

The body frame has fiducial along both sides for accurate planning & set up

It also has diaphragm control to minimize Respiratory movement
• Dedicated Respiratory Belt option
• 3 different sized bridges for different patient sizes
• 210cm Carbon Fibre or 142cm Kevlar platform

• Dedicated Respiratory Belt option
• ONEBridge™ uniquely fits all patient sizes with Lateral & Tilting Offsets
• 183cm lightweight Kevlar ONEPlatform™ has 3 lateral offset options
CIVCO SBRT Motion Management Systems

**Body Pro-Lok ONE™ System**
- + ONEPlatform™

**Body Pro-Lok™ System**
- + Platform

**Overlay Option:** can be used on any couchtop

**No Overlay Option:** specific to certain couchtop indexing systems

**Body Pro-Lok™ Rails-Only System**
## Pros & Cons of Using Overlays

<table>
<thead>
<tr>
<th>PROS:</th>
<th>CONS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Standardisation – allows easy matching between all couchtops with simple connection with standard Lok-Bars</td>
<td>■ Adds attenuation</td>
</tr>
<tr>
<td>• Allows for greater lateral offset if needed.</td>
<td>■ Requires more dose calculations</td>
</tr>
<tr>
<td></td>
<td>■ Can be unwieldly to move between rooms</td>
</tr>
<tr>
<td></td>
<td>■ Requires more storage space.</td>
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</tbody>
</table>
SAXONS

Images of various equipment and components related to SAXONS.
In-house

Breast Board

Arm Rest

Belly Board

Knee Rest
# Perspex Vs Thermoplastic mask

<table>
<thead>
<tr>
<th>Mask type</th>
<th>Anteroposterior</th>
<th>Cranio-caudal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SD (mm)</td>
<td>% deviations &gt; 4mm</td>
</tr>
<tr>
<td>Plastic (cut out)</td>
<td>2.2</td>
<td>5.1</td>
</tr>
<tr>
<td>Plastic (intact)</td>
<td>1.7</td>
<td>3.1</td>
</tr>
<tr>
<td>Orfit (cut out)</td>
<td>2.2</td>
<td>9.2</td>
</tr>
<tr>
<td>Orfit (intact)</td>
<td>1.9</td>
<td>3.3</td>
</tr>
</tbody>
</table>

- Randomized study
- Four arms:
  1. Plastic orfit cut
  2. Plastic orfit no cut
  3. Thermoplastic orfit cut
  4. Thermoplastic orfit no cut
- 43 pts of ENT tumours
- Error estimated with 2D EPID

No difference in set up errors

Weltens IJROBP 1995
3 clamp versus 4 clamp mask

- Randomized study.
- \( n = 241 \) (3 clamp: 120; 4 clamp: 121)
- Port films compared manually

<table>
<thead>
<tr>
<th>3 clamp vs 4 clamp</th>
<th>Absolute difference (mm)</th>
<th>( P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field shift (1\textsuperscript{st} Week)</td>
<td>-6.0</td>
<td>0.22</td>
</tr>
<tr>
<td>Field shift (4\textsuperscript{th} Week)</td>
<td>-1.8</td>
<td>0.69</td>
</tr>
<tr>
<td>Any field shift</td>
<td>-4.4</td>
<td>0.45</td>
</tr>
<tr>
<td>Field shift related to mask</td>
<td>-0.2</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Smaller mask: No compromise in setup reproducibility
Shoulder immobilization and movements: an issue

Sharp L et al; IJROBP
Errors with different fixation devices

Randomized comparison of set up error between 3, 4 & 5 clamp mask (N=30)

• Setup uncertainties: 2-5 mm in AP, CC or ML directions

<table>
<thead>
<tr>
<th></th>
<th>Systematic 3D error mean (SD)</th>
<th>Random 3D error (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Head</td>
<td>Neck</td>
</tr>
<tr>
<td>3 Clamp mask</td>
<td>3.1 (1.0)</td>
<td>2.3 (0.8)</td>
</tr>
<tr>
<td>4 clamp mask</td>
<td>2.4 (0.8)</td>
<td>1.7 (1.0)</td>
</tr>
<tr>
<td>5 clamp mask</td>
<td>2.4 (0.9)</td>
<td>2.2 (1.0)</td>
</tr>
</tbody>
</table>

Gilbeau et al. Radiother Oncol 2001
Organ motion often is categorized as follows:

- **“Interfraction”** motion occurs between fractions and primarily is related to changes in patient setup daily.

- **“Intrafraction”** motion occurs during fractions and primarily is related to respiration, cardiac motion, and the digestive system.
Inter-fraction / Intra-fraction movement

*Intra-fraction error*
- Deviation observed within a single fraction of fractionated therapy.
- Caused by random / periodic patient movements (e.g. Breathing).

*Inter-observer variation*
- Due to manual matching of a reference image and a portal image can also introduce substantial measurement errors.
How To Limit Motion?

- **Simple techniques**
  1. Patient immobilization (molds, casts, etc)
  2. Breath control
    (Breathing Training)
  3. Abdominal compression.
  4. Beam gating
    (observation of chest wall motions)

- **Complex techniques**
  1. Deep Inspiration Breath Hold
  2. Active Breathing Control (ABC)
  3. Real Time Tumor Tracking
  4. IGRT (respiratory gating and real time position management)
Organ Motion Control

Deep Inspiration Breath Hold

Abdominal Compression

Active Breathing Control

Real Time Tumor Tracking

Respiratory Gating
Electronic Portal Imaging Device (EPID)

- 1980s…. Norman Baily
- Commercial EPIDs in 1990s

Types of EPID
- Liquid ionization chamber based
- Camera based
- Amorphous silicon based

Advantages of EPIDs
- Images available immediately
- Images can be used for online correction
- Digital images: can be enhanced by changing contrast and brightness
- Used for matching with DRR image.
KV CT: On-Board Imager (OBI)

Treat what you have planned
providing the ability to deliver more accurate
treatment with confidence and repeatability

High quality Imaging.
Low dose to patient (< 4cGy)
Choice of imaging modalities
Easy-to-use user interface with automated
comparison tools
Automated extension and retraction of OBI

Matching with soft tissue delineation
MV CT: Tomotherapy

MV CT based contour matching
Mould Room Techniques

- Immobilization Masks
- Conformal Blocks
- Electron Cutouts
- Tissue Compensators
- Oral Prosthesis
- Brachytherapy Moulds
Styrofoam cutter and customized blocks

Low melting alloy, $\rho = 9.3$ gm/cc
Ostalloy- Bi-50%, Pb-25%, Cd- 13%, Tin-12%
Conformal block: size depends on distance
3D Styrofoam cutter - Milling machine

• one can export just the fluence to MM’s computer & it can also convert it into compensator thickness file
Aluminum blocks Tissue Compensator

JIG
Aluminum Blocks
Measurement of air gap
Final Shape
Treatment

Aluminum Blocks Final Shape
BITE BLOCK
HDR Brachytherapy Surface Moulds
Making the mould
Making the mould
IMPLANT ACCESSORIES

CROSSING TUBES

STRECHING IMPLANT TUBES

BREAST TEMPLATES
Preparation of Bead tubes

• Commercially available beads have only a single passage

• For cross beads, we need a passage perpendicular to the original passage

• A Third hole is made with a bur attached with a heavy duty dental motor
Trolley arrangement
CONCLUSION

- With increasing trend of conformal treatments the importance of immobilization has multiplied many folds
- Appropriate positioning is pre-requisite for proper immobilization
- Simple in-house devices can be designed for positioning
- Thermoplastic sheets are most common and effective method of immobilization
- It is necessary to choose carefully various H & N rests based on institutional protocols
- Considering high costs of sophisticated immobilization devices it is prudent to include detail immobilization requirement along with procurement of treatment units
- In brachytherapy there is good scope of mould room techniques to prepare HDR moulds and other accessories for implants
IMMOBILIZATION - BE DEFINITELY BETTER THAN GULIVER'S!
Thank you