Image Guided in Radiation Therapy (IGRT)

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EBT Process

Diagnosis
- X-ray
- CT
- MRI
- NM
- Patho

Simulation

Tx Planning

Tx Verification

Tx Delivery

EBT Process
Process of Care for ERT

**Preparing for treatment**
- Simulation (Imaging for planning)
- Treatment planning (pre-treatment review)
- Pretreatment verification

**Treatment**
- Treatment setup (Image guidance: IGRT)
- Treatment delivery (IGRT review)
- On treatment verification
Positioning and Immobilization is still key to reduce set up error!!
In many cases it is not enough.
IMMOBILIZATION DOES NOT ALWAYS WORK!
Tumors Shrink

Bladder

Tumor

Rectum

Week 1

Prescription Isodose

Bladder

Tumor

Rectum

Week 3
Tumor shrink

Nasopharyngeal Cancer

Day 1

Day 17

Day 27

Todd Pawlicki PhD (UCSD)
• All tumor motion is complex

- Some motion is mostly Anterior / Posterior
- Some motion is mostly Superior / Inferior
- All tumor motion is Complex

Cross-sectional View of Patient’s Chest

Tumor Motion During Respiration
The tumor moves with time

Set-up Error
Organ Motion
Organ Deformation

Set-up Error
Organ Motion
Patient positioning and verification
<table>
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<th><strong>Image Guided in Radiation Therapy (IGRT)</strong></th>
<th>MV EPID</th>
<th>kV Fluoroscopy + markers</th>
<th>Ultrasound</th>
<th>kV CT</th>
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<tbody>
<tr>
<td>MV CT</td>
<td>MV cone beam CT</td>
<td>MV cone-beam CT</td>
<td>kV Cone-beam CT</td>
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What is IGRT?

Prefer a more focused definition

• **Distinguish between**

  - Image-based RT.... use of imaging to define the target and normal tissues for treatment planning

  - **Image-guided RT ..... use of imaging to monitor and modify treatment**
The vision is to detect deformations and motion between fractions (inter-fractional IGRT) and during irradiation (intra-fractional IGRT), and to correct for these changes either by gating or tracking of the irradiation beam.
It is critical to keep the consistency of the patient geometry throughout the whole treatment course.
Portal Films

- Taken during (or directly before) treatment with:
  - beam from the treatment unit
  - patient in treatment position
  - shielding in place
Electronic Portal Images

- A filmless way to verify field location
- Mounted on the linac
MEGAVOLTAGE IMAGE

Portal imaging

Not Clear
Not Well Defined
CLEAR WELL DEFINED IMAGE
Current IGRT Technologies

Radiographic localization systems

Non-radiographic localization systems
Current IGRT Technologies

A. Portal imaging
B. Radiography
C. CT
D. Fluoroscopy

A. Ultrasound
B. Video based Laser based surface imaging system
C. RF Tracking
Radiographic localization systems
A. Portal imaging

B. Radiography
   B.1. CyberKnife
   B.2. BrainLab ExacTrac system
   B.3. **Gantry-mounted** kilovoltage imaging system

C. Computed tomography
   C.1. CT-on-rails
   C.2. kV Cone-beam CT
   C.3. MV Fan-beam CT
D. Fluoroscopy

D.1. C-arm fluoroscopy

D.2. Varian on-board imager OBI and Elekta synergy XVI

D.3. Dedicated in-room fluoroscopy (Hokkaido University School of Medicine).
Room-Mounted X-Ray Systems

CyberKnife imaging system

Radiography
Room-Mounted X-Ray Systems

Novalis/TrueBeam imaging system
TrueBeam STx system?

- aSi Flat Panel Detectors
- Infrared Camera System
- Infrared Camera System
- OBI
- Flat Panel Detectors for KV x-ray
- X-ray Tube
- BrainLAB Couch Mount
“Exac Trac 2”
Room based KV imaging system
(Real time tracking radiation therapy)
Gantry-Mounted X-Ray Systems

Elekta Synergy XVI and On-Board Imager OBI that can be used in radiographic, fluoroscopic, and cone-beam CT modes.
C. Computed tomography

*kV Cone-beam CT*
CT-on-rails
MV Tomographic Imaging

3.5 MV Photon for CT Imaging

Tomotherapy Unit

YouTube - Tomotherapy - Revolutionary Radiation Therapy.flv
Vero System

- BrainLAB – Vero System

CBCT options
Linac and MLC on gimbals
Extremely rigid O-Ring structure
Dual diagnostic imaging capabilities
→ **Stereo x-ray**, dual fluoro and Cone Beam CT
Non-radiographic localization and positioning systems
3D Autopositioning (ExacTrac)
Ultrasound Planning

Treatment
US ACQUISITION

SEGMENTATION

COMPARISON

COUCH MOVING

REGISTRATION

Scan

Treatment
Radiofrequency tracking
VisionRT is a video-based three-dimensional (3D) surface imaging system. It uses images of skin surfaces of a patient in 3D before and during radiotherapy treatment.
Optical systems_Patient surface tracking (C-Rad)

The Catalyst is a laser positioning scanning system used for patient set-up, patient monitoring and gating within radiotherapy.

The system consists of a projector which projects light on the desired surface and a camera that captures the projected light on the surface.
Thanks!!

“No matter how good is the beam, if the target is not where we thought”.

[Cartoon image of a medical professional adjusting a target while another person is being treated incorrectly.]
Task Group 75: The management of imaging dose during image-guided radiotherapy
Task Group 104: The Role of In-Room kV X-Ray Imaging for Patient setup and Target Localization
Task Group 135: Quality Assurance for Robotic Radiosurgery
Task Group 142: Quality assurance of medical accelerators
Task Group 154: Quality Assurance of Ultrasound-Guided External beam Radiotherapy for Prostate Cancer
Task Group 179: Quality Assurance for image-guided radiation therapy utilizing CT-based technologies