The RTOG is working diligently on incorporating IGRT into protocols

Internally – through the ATIC and the Medical Physics Committee

Externally – with the RPC and the ITC

The Use of IGRT in RTOG Protocols

- Like the introduction of IMRT for tailoring dose distributions, IGRT promises to reduce critical structure sparing through margin reduction
- Like IMRT, the use of IGRT must be carefully controlled when used in a cooperative group protocols

What has the RTOG done to control IGRT in their protocols?

Definition of Image Guided Radiation Therapy

- Process extending from CT-simulation imaging through the step of imaging the patient on the treatment unit
  - Process includes the following steps:
    - Manual or automatic registration of the two datasets
    - Determination of a series of mechanical movements of the patient support system to correct for detected positioning errors

RTOG
Radiation Therapy Oncology Group

Many Different Approaches to IGRT

- There are many different ways of imaging the patient in the treatment room
- There are many different ways for registering the CT-sim and IGRT datasets
- There are many different ways for adjusting the patient’s position based on registration information

Guidelines for including IGRT in RTOG Protocols

- **Protocol must include:**
  - **IGRT Specifications**
  - **IGRT Questionnaire**
  - **Phantom Irradiation**
  - **Image Registration Software Tests**
    - Tests that use patient datasets
  - **Controls on Patient Peripheral Dose**

IGRT Questionnaire

a. kV cone-beam (2D or 3D match)

b. Dual kV imaging panels (eg, ExacTrac, Cyberknife)

c. Helical MV tomography

d. MV cone-beam

e. In-room diagnostic CT scanner

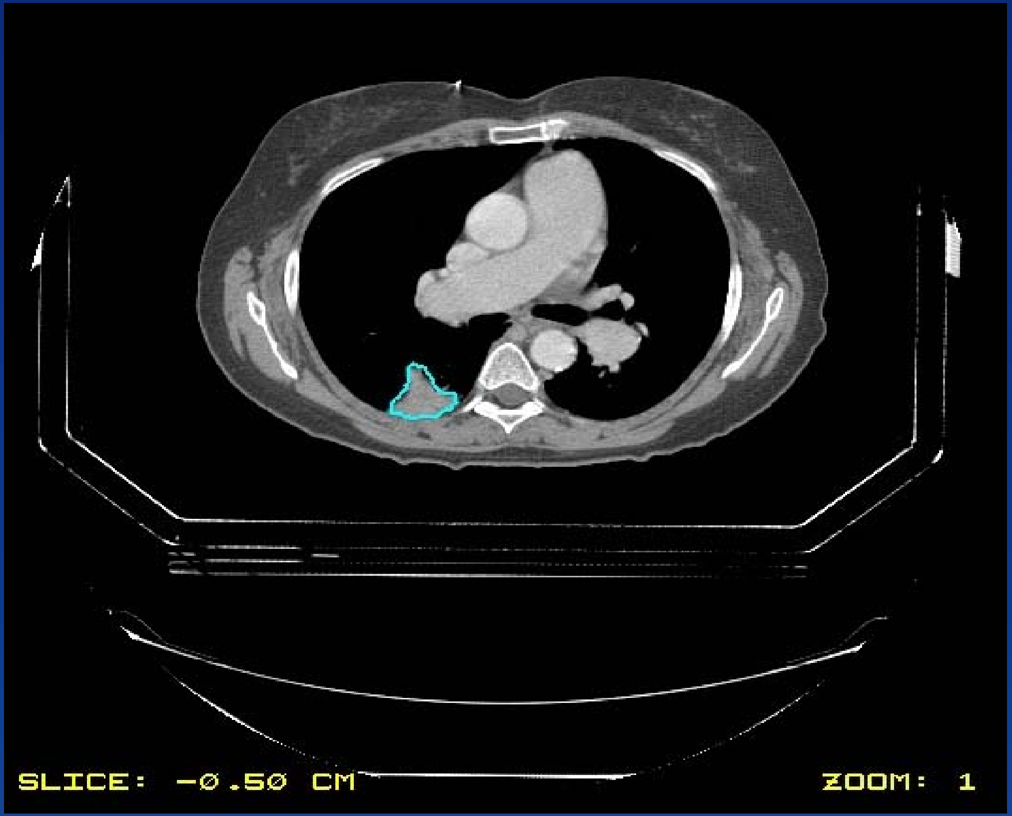
f. kV or MV Stereoscopic images using EPID

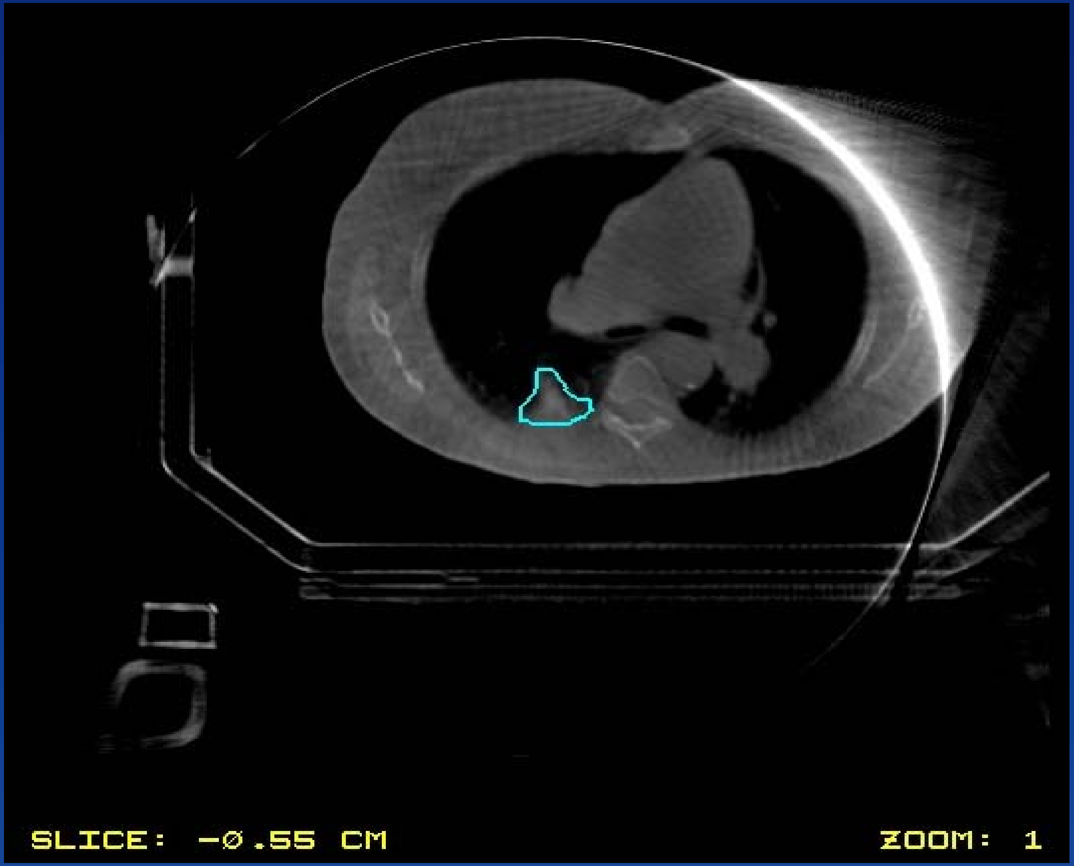
g. other (describe)______________________________

IGRT Questionnaire

- a. automatic registration, b. manual click drag and rotate, c. other (describe) ______________________
- a. split screen b. spy glass c. color fade d. other (describe)______________________________________
- a. each day, b. each week, c. each month, d. yearly, e. not done, f. other ___________________________

ITC Remote Review Tool





Current Efforts of ATIC and Medical Physics Committee

- Controlling patient peripheral dose from IGRT
  - Imaging frequency
  - Imaging technique
  - Imaging volume

Reason for Increased Peripheral Dose for Radiation Therapy Patients

- **Intensity Modulated Radiation Therapy (IMRT)**
  - Increased leakage radiation
- **Increased Planning dose**
  - CT scanning in general
  - 4D CT Planning in particular
- **Increased Imaging as Part of Daily Treatment**
  - New technologies are easy and helpful to use daily

Useful Publications

- Martin J. Murphy, et al The management of imaging dose during image-guided radiotherapy - Report of the AAPM Task Group 75 *Medical Physics* 34, 4041-4063, 2007
- Mohammad K. Islam, et al Patient dose from kilovoltage cone beam computed tomography imaging in radiation therapy *Medical Physics* 33, 1573-1582, 2006

Other Contributions to Peripheral Dose

- **Leakage Radiation**
  - 0.2% or less
  - IMRT decreases efficiency so that leakage goes up by x3
  - Thus, 60 Gy target dose gives about 360 mGy leakage dose
- **Scatter Dose and Dose from Non-coplanar Fields**
  - Near target volume receiving 60 Gy, scatter can be 300-3000 mGy (10 to 1 cm away)
- **Single planning CT study**
  - 30-50 mGy (4D CT about a factor of 3 higher)
- **Standard portal imaging**
  - Film 50-100 mGy per image EPID 10-50 mGy per image

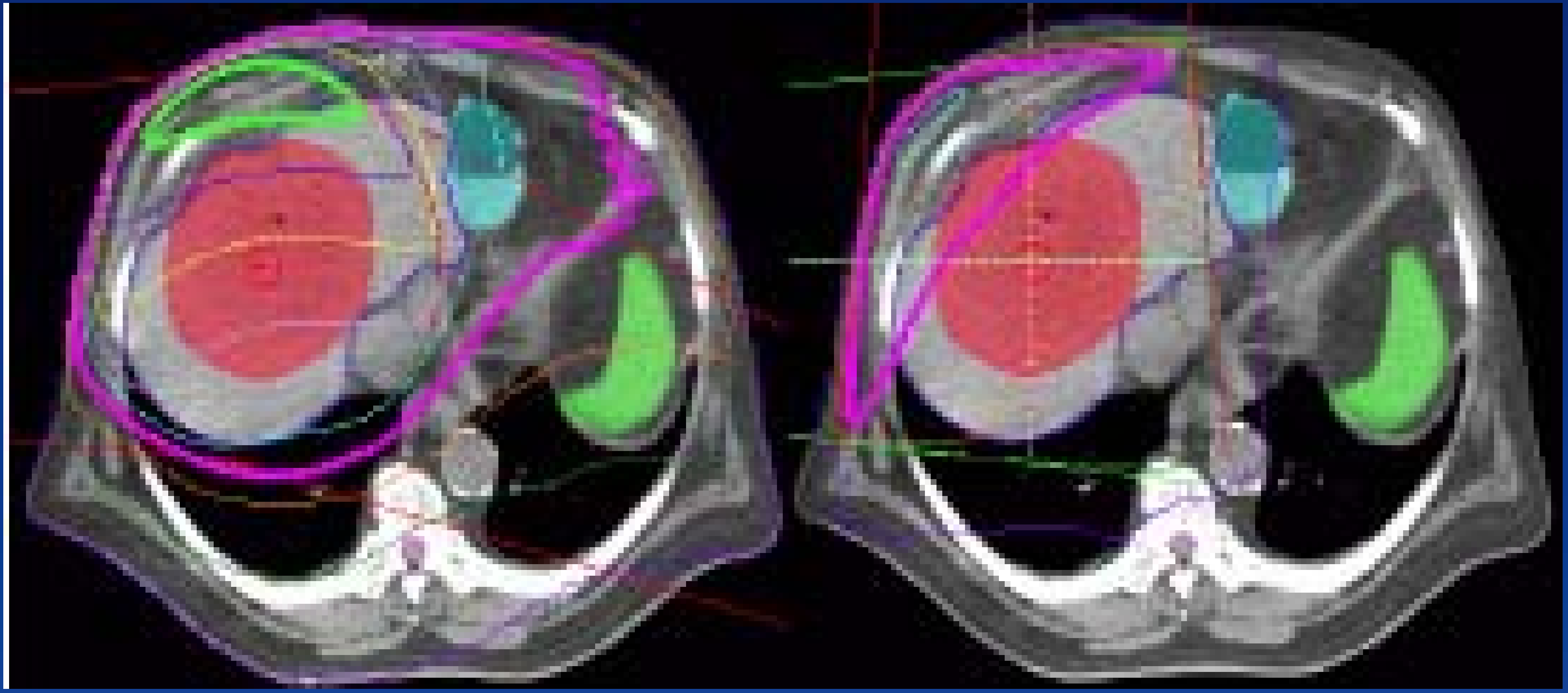
Peripheral Dose from IGRT

- **Elekta Cone-Beam CT**
  - Mean dose at center — Head/Torso — 23/16 mGy
- **TomoTherapy Helical MV CT**
  - Depends on pitch, slice thickness — Head/Torso — 25/18 mGy
- **Varian Cone-Beam CT**
  - Depends on bow-tie filter, degrees of rotation, grid? — Head/Torso — 83/42 mGy
- **Siemens MV Cone-Beam CT**
  - MV cone-beam — 50-150 mGy

Peripheral Dose from IGRT

- **Elekta Stereoscopic kV Imaging**
  - Dose about a factor of ten less than cone-beam with same unit

Peripheral Dose from IGRT



Lee-Cheng Peng, et al J Appl Clin Med Phys Vol 8 No 1(2007)

9 MU MV cone-beam CT

4 MU orthogs

Dose Reduction Strategies for Cone-Beam CT

- Minimize the longitudinal field of view
- Reduce number of projections and/or the mAs settings per projection
- Use a lower kV
- Scan with partial rotation

Islam, et al

Dose Reduction Strategies for IGRT – The NKI Technique

- Use the first week of treatment to define systematic errors with daily imaging
- Correct and image weekly thereafter

Conclusions

- This is still a Work-in-progress
- However, many important components are now in place

Probability of Inducing a Fatal Cancer

- ICRP coefficient for estimating the probability of inducing a fatal cancer from a single radiographic exposure is $5x10^{-5}$ per mSv of effective dose

Probability of Inducing a Fatal Cancer

- Consider a prostate treatment that uses CT for planning followed by 30 daily portal image pairs at 2 MU each.
- For the CT part of the procedure, the Effective Dose has been estimated at 8.2 mSv
- For the portal imaging part of the procedure, the Effective Dose is estimated as 1.3 mSv
- The total Effective Dose is 8.2 + 30x1.3 = 47.2 mSv
- Thus, using the equation from the previous slide, there is an estimated probability of 0.2% for radiation-induced cancer in the patient's lifetime.

Probability of Inducing a Fatal Cancer

- Consider a thirty-year-old female being treated for cervical cancer. If this patient undergoes 30 complete daily in-room CTs for targeting and compensation of organ deformation, she receives an estimated Effective Dose of 246 mSv.
- This situation gives a 1.2% probability of a radiation-induced cancer.

Dose Reduction Strategies for IGRT

- Configure the image acquisition systems to eliminate dose outside the required fields of view
- Plan the imaging technique to be consistent with the image quality and information needed for the treatment decision being made

Murphy, et al

IGRT Methodologies Not Currently Included

- **The guidelines presented here do not include IGRT techniques that use ultrasound or infrared systems that place fiducial markers on the patient's skin**
- **Deformable fusion techniques are not included at this time**