The Effects of Motion on IMRT: Methods to alleviate IMRT motion effect errors

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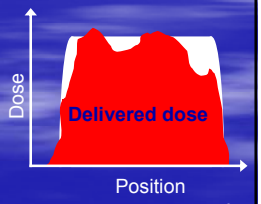
Thanks to Steve Jiang and Rohini George for slides

What have those guys been trying to tell me?



Techniques to treat mobile tumors

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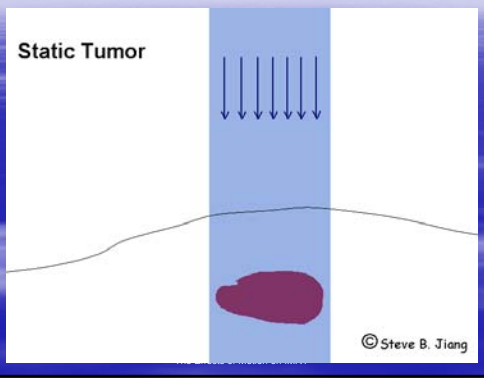
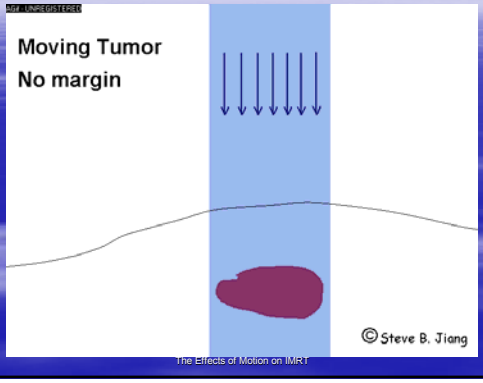


Techniques to treat mobile tumors



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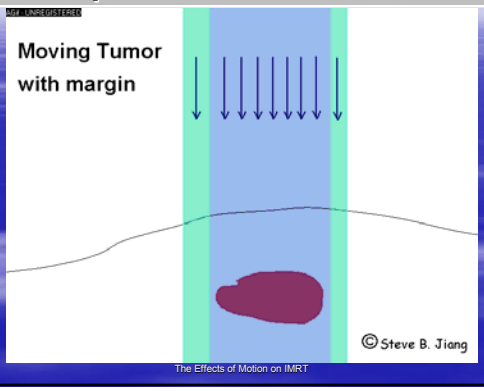
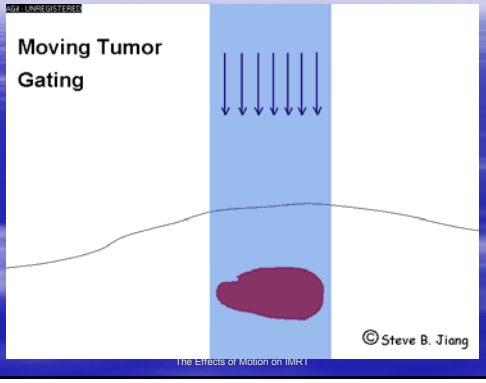


Techniques to treat mobile tumors



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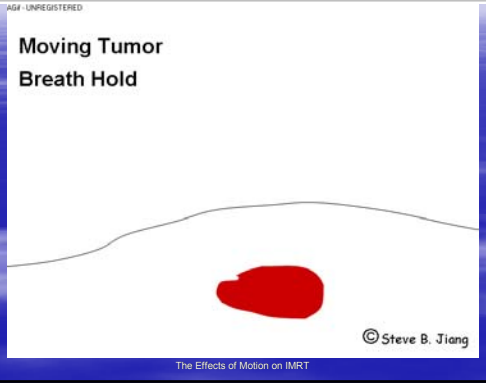

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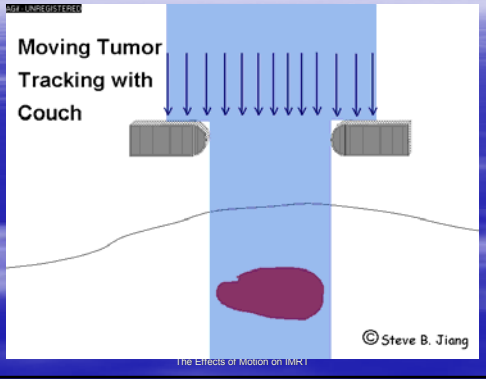
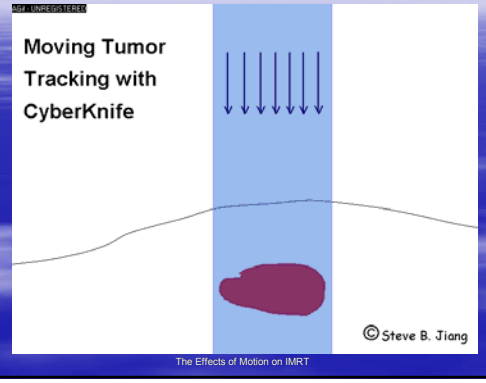
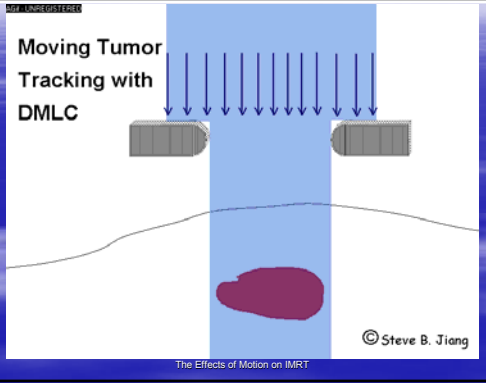


Techniques to treat mobile tumors



Techniques to treat mobile tumors



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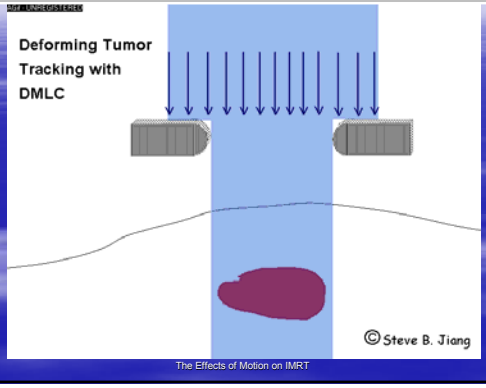
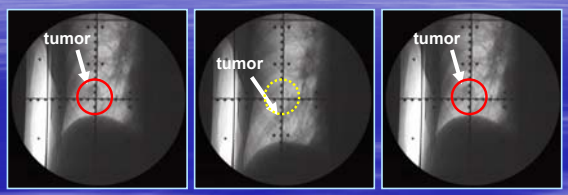


Organ motion

- Occurs while the patient is being irradiated
- Caused by respiration motion, cardiac motion and the digestive system
- Methods to account for intra-fraction motion
  - Respiratory gating techniques
  - Active breathing control (ABC)
  - Deep Inspiration breath hold (DIBH)
  - Voluntary breath hold (VBH)
  - Dynamic tumor tracking/4D radiotherapy
  - Abdominal compression?

Respiratory gating

Respiratory Gating



Beam ON | Beam OFF | Beam ON

Respiratory Gating

- Radiation delivery synchronized with the respiratory signal
- A reflective marker block is placed on the patient to detect respiration motion (or internal fiducial markers)
- Marker blocks are illuminated by infrared emitting diodes
- Software tracks the position of the marker

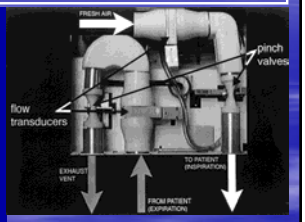
Respiratory Gating
Advantages and disadvantages

- Advantages
  - Reduction in volume of normal tissue irradiated
  - Fewer motion artifacts in CT scan
  - Patients do not need to hold breath
- Disadvantages
  - Residual motion within gating window
  - Not robust to baseline shifts
  - Treatment time increases

Breath hold techniques

Active Breathing Control (ABC)

- Temporarily immobilizes patients breathing
- The inspiration and expiration paths of airflow are closed at a predetermined flow direction
- Figure shows ventilator which was used for ABC (modified Servo Ventilator 900C)



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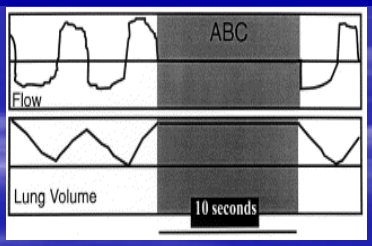
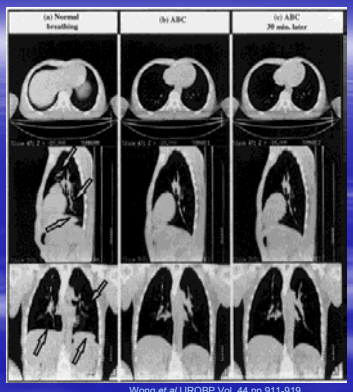
Airflow and lung volume

- Airflow and lung volume during normal breathing and ABC level
- ABC in this case activated for 10 s



CT scans

- Acquired during normal breathing
- Acquired with ABC applied for 43 s during deep inspiration
- During ABC at the same deep inspiration phase but 30 min later



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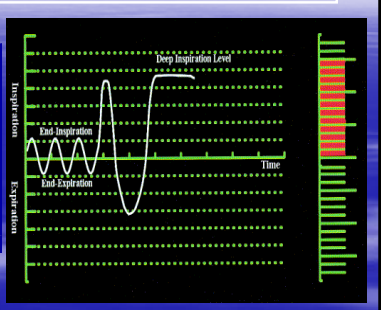
Deep Inspiration Breath Hold (DIBH)

- DIBH involves coaching the patient to reproduce deep inspiration level during simulation, radiation treatment and port film verification

Spirometry tracing

- Quiet tidal breathing initially established
- Verbal coaching
  - Slow deep inspiration
  - Slow deep expiration and then
  - A second slow deep inspiration and then
  - Breath hold



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Set-up for DIBH

- Patient is placed in supine position in an immobilization device
- Patient is connected to a spirometer
- Nose clips are attached to prevent nasal breathing

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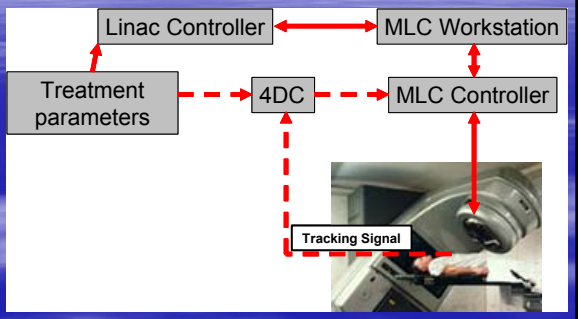
Breath hold
Advantages and disadvantages

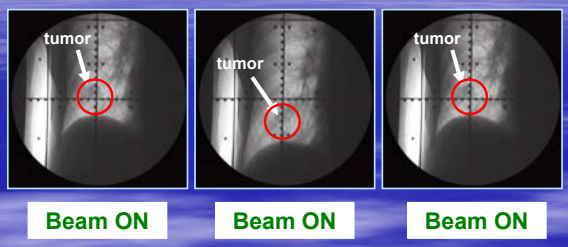
- Advantages
  - Reduction in volume of normal tissue irradiated
    - Reduction in internal motion, and
    - Reduction in fractional lung irradiated/increase in heart-chest wall separation
  - Fewer motion artifacts in CT scan
- Disadvantages
  - Treatment time increases
  - Patient compliance
  - Internal motion during breath hold

4D Radiotherapy

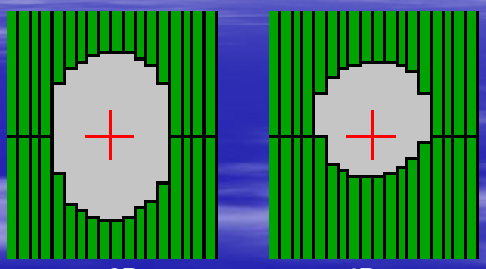
4D radiotherapy delivery



4D radiotherapy delivery



MLC leaf motion



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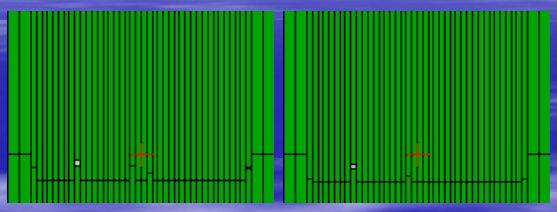

For more on respiratory motion management in radiation oncology …

Tuesday July 27
8:30 am
Room 303