FRACTIONATED RADICAL RADIOTHERAPY FOR NSCLCA: OVERVIEW (PATIENT SELECTION, IMAGING REQUIREMENT, TREATMENT PLANNING CONCEPTS)

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FRACTIONATED RADICAL RADIATION THERAPY

- Available for different stages of Disease I-III
- High dose Stereotactic RT for early stage disease (where surgery is not being considered)
- Concurrent Chemotherapy and Radiation therapy
- Altered Fractionation RT (CHART) is yet another standard of care
- Dose and fractionation of RT depends often on :
  Patient related factors
  Tumour related factors
  Local experience and choice

RADICAL : CURATIVE RADIOTHERAPY

- Check eligibility

Patient related factors:

General PS (Curative, CTRT, Radiation,Palliative)

Co morbidities

Specifics of Pulmonary Function tests

- Tumour related factors:

Staging on CT Scan/PET Scan

Look at involved nodal stations

Extent of primary disease wrt fixed structures

RADIATION THERAPY PRACTICAL CONCEPTS:

Concept 1: Patient Selection (Stage I-III)

- Clinical Trials on chemoradiation had a highly selected group of patients
- 43% <60yrs old
- 97% had WHO PS score of 0-1
- Almost all patients had a FEV1 and DLCO >50%

PET CT SCANS FOR TREATMENT PLANNING

- PET/CT is preferred imaging to detect atelectasis from intra tumour heterogeneity in NSCLC (Nestle et al.,1999)
- It has higher sensitivity and specificity for identifying lymph node involvement
- PET/CT is associated with smaller tumour volume than compared with radiotherapy planning CT (Bradleyetal.,2004;Hannaetal., 2010; Molleretal.,2011)
- For co registered images strict replication of immobilisation, positioning is required
- Post chemotherapy FDG accumulations may not be regarded as representative for the GTV
- In General, PET CT is used as an adjunct to treatment planning CT scans

CONCEPT 3: PLANNING CT SCAN

- The entire volume of both lungs should be included in the planning CT scan in order to accurately calculate dose–volume histograms (Cricoid Cartilage to L2 vertebra)
- A single axial or spiral planning CT scan acquired during free breathing is not an optimal study, because it may capture the random position of a tumour 40
- CT slices of 2–3 mm enables high-resolution digitally reconstructed radiographs (DRR) and better identification of mediastinal nodal structures
- Using intravenous contrast can improve the delineation of centrally located primary tumours [39]
- In the absence of higher CT scanners a SLOW CT scan may be required

I CAN CALCULATE THE MOTION OF HEAVENLY BODIES, BUT NOT THE MADNESS OF PEOPLE.: ISAAC NEWTON

Moving Target

MOVEMENT OF LUNG CANCERS

- Understanding the problem
- Identifying the problem
- quantifying the problem
- Addressing the problem

WE ARE TALKING ABOUT PROBABILITY

- GTV- What we see is the best possible that can be seen- This is what Radiologists and radiation oncologists do

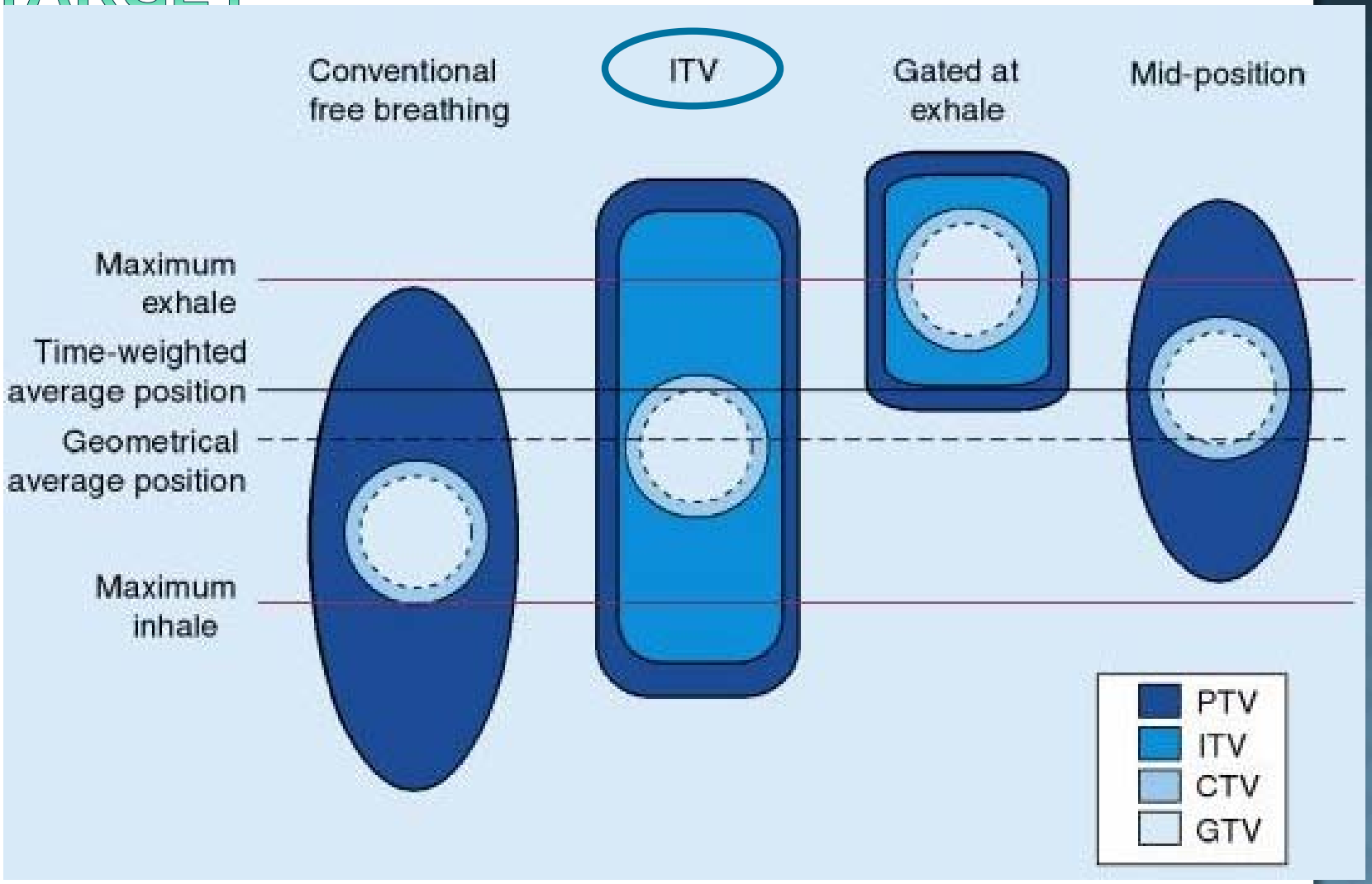
- CTV- The Anatomical and clinical probability of disease affecting areas- That is what radiation oncologists do

- PTV- This is a geometrical tool; This ensures that the probability of the CTV to be treated to the prescribed dose is high.

4D TREATMENT PLANNING CT SCANS

- 4D is referring to the motion of target volumes and organs at risk during the delivery of each fraction of radiotherapy
- These scans provide information of movements of Target and OARs with time (respiration).
- 4D-CT provides information on the motion of mediastinal structures, such as lymph nodes, which may differ significantly from that of the primary tumor
- Repeat 4D-CT does not add more/ change information from single scan.

THE CONCEPT OF A MOVING TARGET



Cox J *et al.* Interruptions of high-dose radiation therapy decrease long-term survival of favorable patients with unresectable non-small cell carcinoma of the lung: analysis of 1244 cases from 3 Radiation Therapy Oncology group (RTOG) trials. *Int. J. Radiat. Oncol. Biol. Phys.* 27(3), 493–498 (1993

MOVEMENTS DURING RESPIRATION

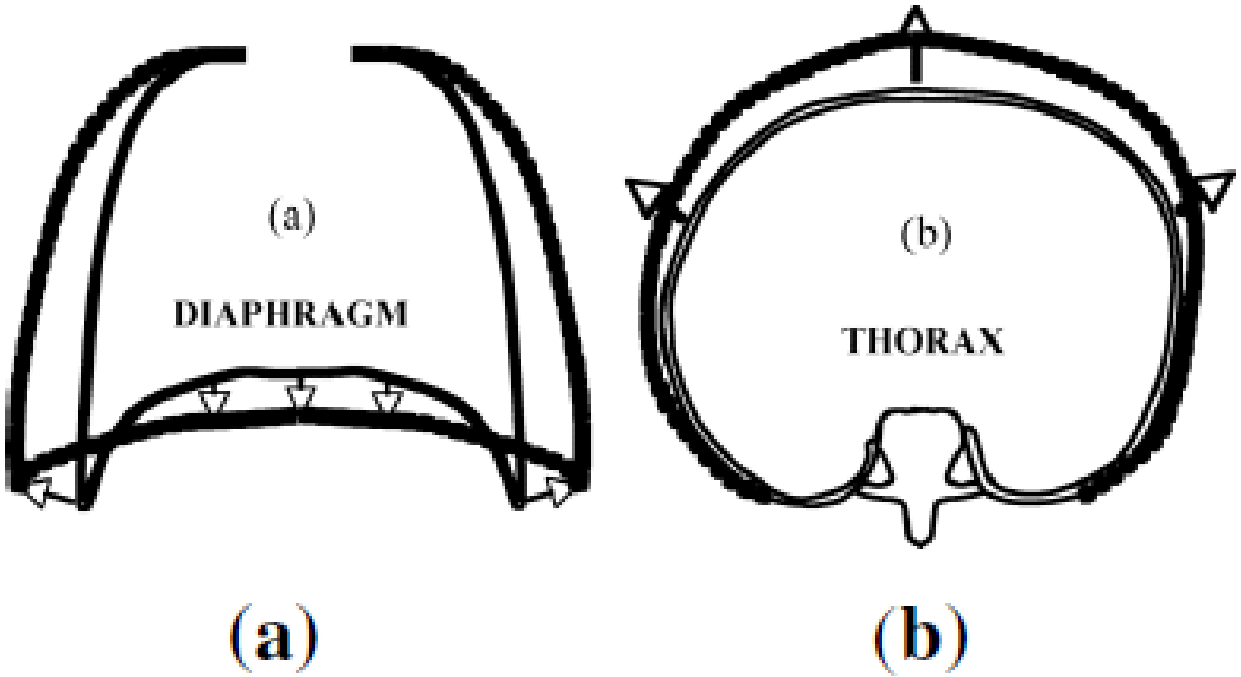
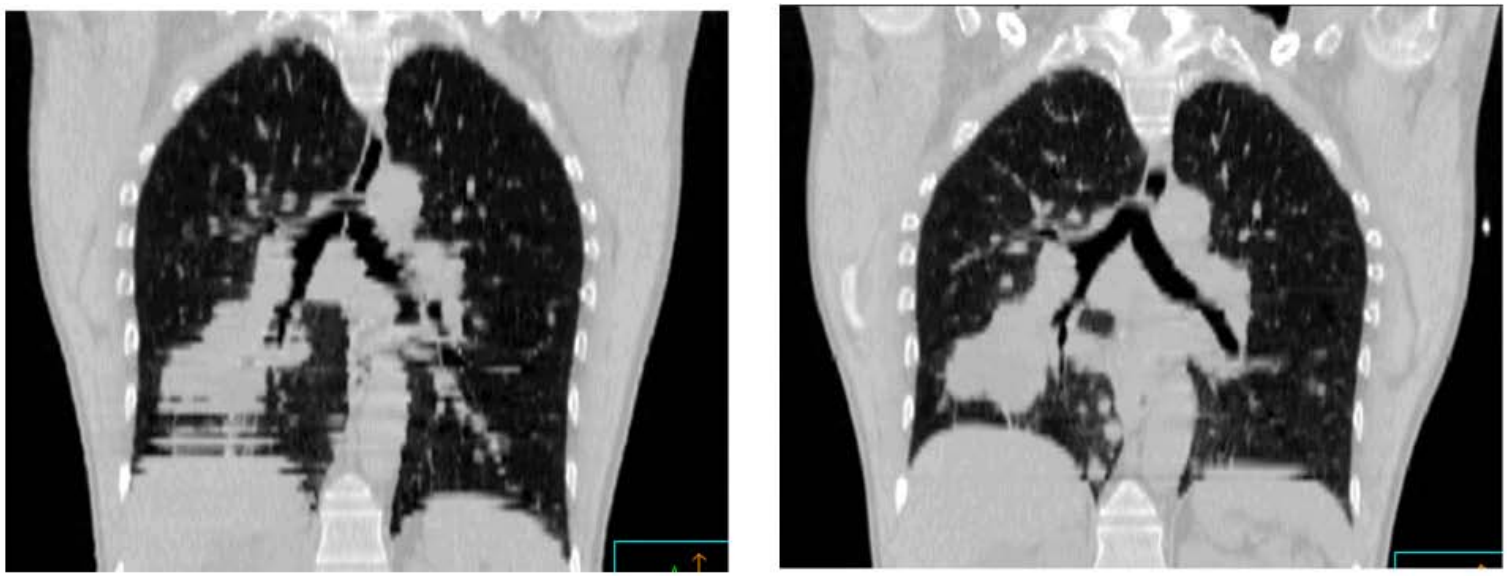


Figure 3. (a) During inhalation, the diaphragm contracts, the abdomen is forced down and forward, and the rib cage is lifted. (b) The intercostal muscles also contract to pull and rotate the ribs, resulting in increasing both the lateral and anterior–posterior (AP) diameters of the thorax. [Reproduced from reference 226: J. B. West, *Respiratory Physiology: The Essentials*, Figures 3a,3b. © 1974, with permission from Lippincott Williams, and Wilkins.]

CONCEPT 4: UNDERSTAND THE CONCEPTS OF ORGAN MOVEMENTS

- locally advanced tumour motion is unlikely to exceed 1.0 cm except for small lesions located in the lower half of the lung
- Techniques such as Breath hold, abdominal compression could be used in select cases
- Gating and tracking are technically challenging techniques that may only be of value in the small subgroup of patients whose tumours show significant motion and if online tumour-based setup corrections are applied.

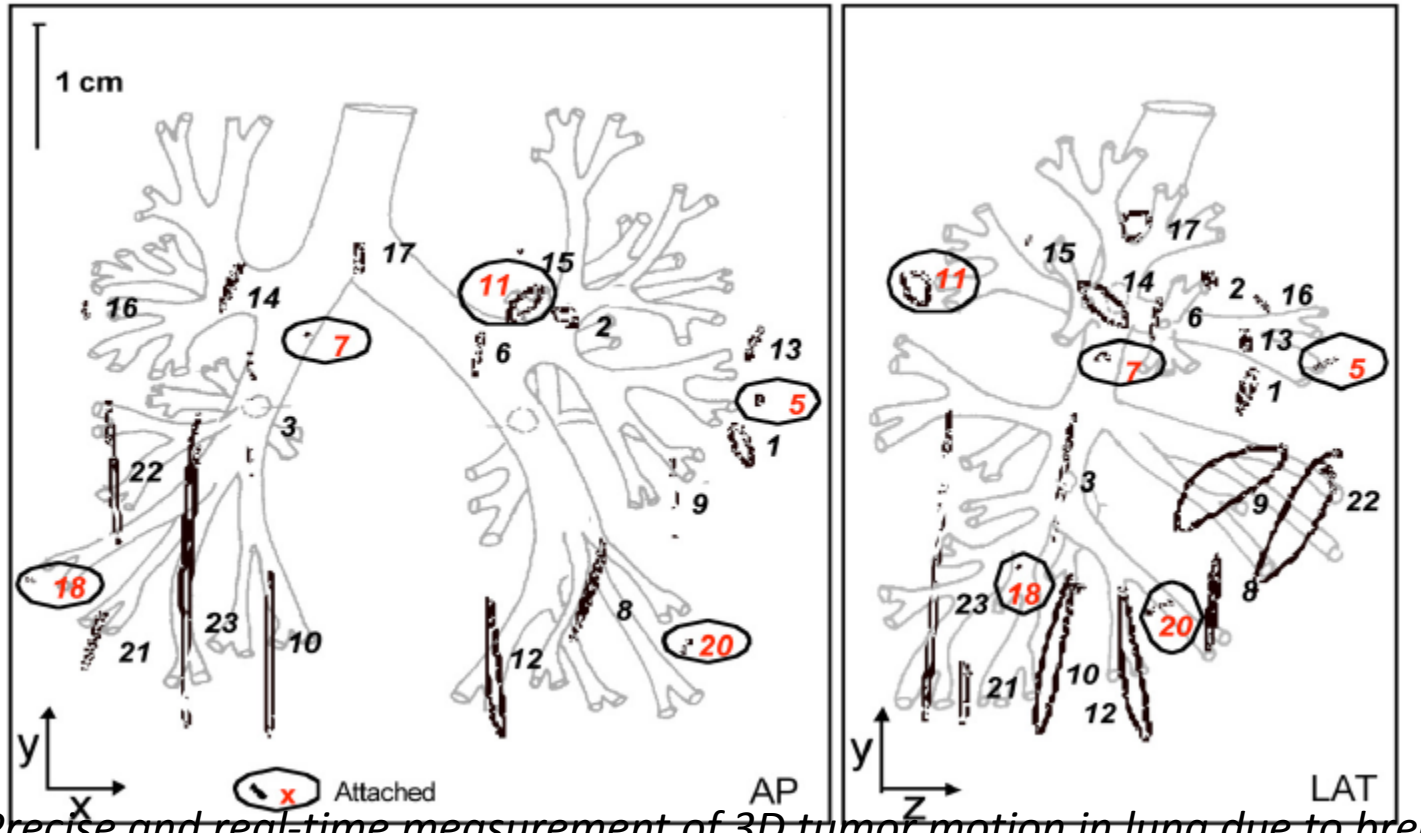
MOVEMENTS : PLANNING CT SCANS



(a) (b)

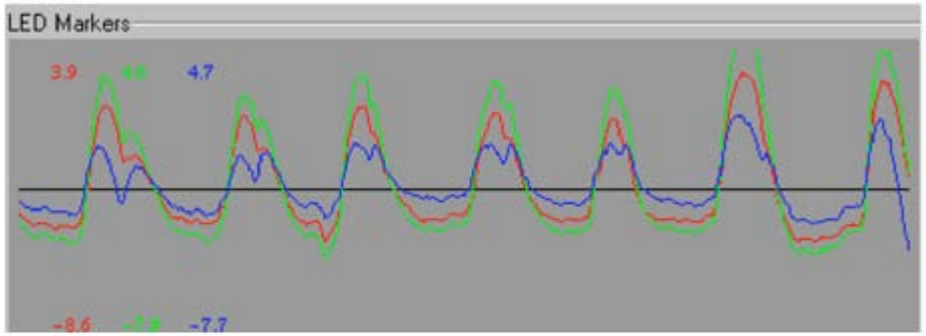
The management of respiratory movements in radiation oncology AAPM 2006

LUNG TUMOUR FIDUCIAL MOVEMENT MEASURED ON FLUOROSCOPY

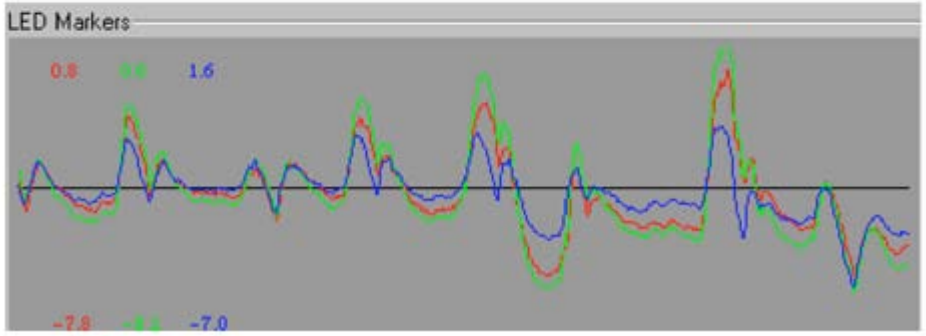


Precise and real-time measurement of 3D tumor motion in lung due to breathing and heartbeat, measured during radiotherapy, *Int J Radiat Oncol Biol Phys, vol 53,* Y. Seppenwooldeet al, 2002, 53:822–834.

VARIATION OF RESPIRATORY MOVEMENTS



(a)



The management of respiratory movements in radiation oncology AAPM 2006

MEASURING MOTION

- Measurement of the movement of a marker in the organ or nearby organ

Lung

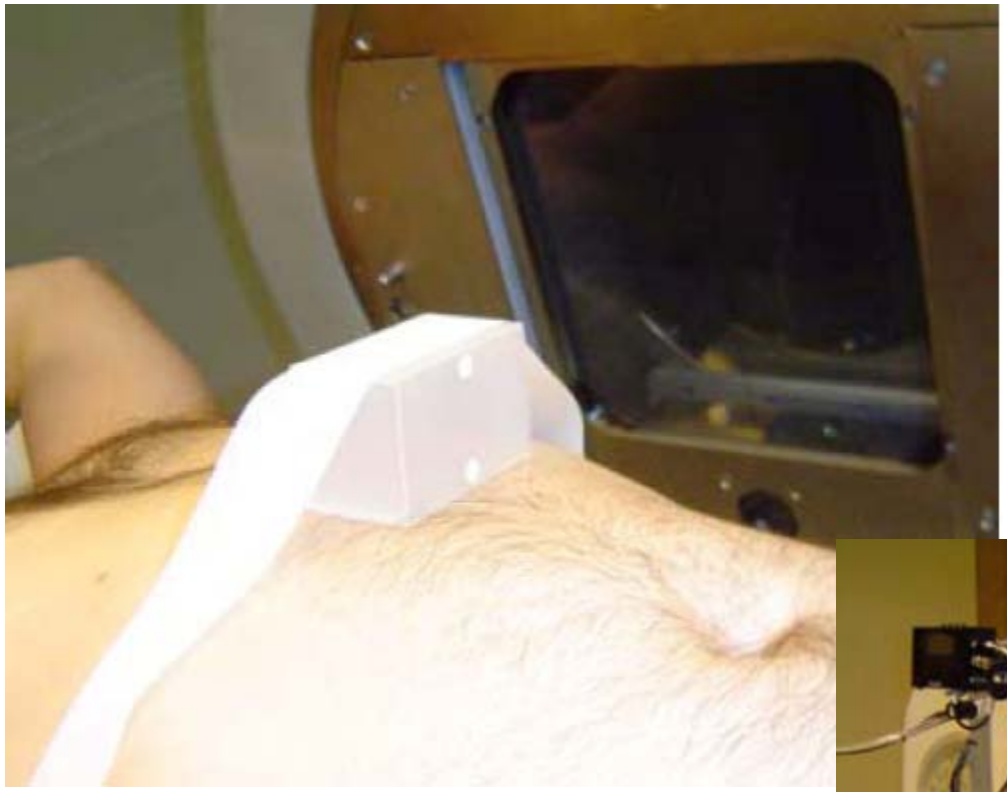
- Indirect measurements: (surrogate) organ movements are measured to give us the probable movements

Diaphragm movements

SIX METHODS AS EXAMPLES OF MEASURES TO INCLUDE WITH RMMS:

- (i) inhalation of oxygen;
- (ii) abdominal compression
- (iii) learning of regular respiratory patterns
- (iv) breath hold technique: active breathing control, self-respiratory cessation in deep inspiration self-respiratory breath-monitoring measured at two thoraco-abdominal points;
- (v) gating with respiration;
- (vi) real-time tumor-tracking: pursuing irradiation and intercepting irradiation.

Guidelines for respiratory motion management in radiation therapy. Matsuo et al Journal of Radiation Research, 2013, 54, 561–568

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ORGAN MOVEMENT MEASUREMENT

Site	Technique					
	CT	MRI	Fluoroscopy	Ultrasound	Nuclear imaging	EPID
Pancreas				Suramo et al.[74] Bryan et al.[75]		
Liver		Korin et al.[79]		Suramo et al.[74] Davies et al.[68]	Weiss et al.[89] Harauz et al.[90]	
Kidney				Suramo et al.[74] Davies et al.[68]		
Diaphragm	Giraud et al.[78]	Korin et al.[79]	Wade et al.[80] Ford et al.[86] Minohara et al.[82]	Davies et al.[68]		
Prostate			Malone et al.[2]			
Lung	Ross et al.[76] Hanley et al.[77] Shimizu et al.[55] Essapen et al.[219] Stevens et al.[66] Sixel et al.[92] Grills et al.[91]	Plathow et al.[220]	Kubo et al.[36] Ekberg et al.[26] Shirato et al.[221] Murphy et al.[83] Chen et al.[84] Engelsman et al.[28] Barnes et al.[85] Shimizu et al.[52] Murphy et al.[87] Seppenwoolde et al.[67] Ozhasoglu et al.[88]			Erridge et al.[101]
Breast						van Tienhoven et al.[35]

CT: computed tomography; EPID: electronic portal imaging device; MRI: magnetic resonance imaging.

WHEN TO IMPLEMENT RESPIRATORY MOTION MANAGEMENT

- When the three-dimensional length of motion exceeds 10 mm (You may wish to do it for less , but it may not be cost effective)

- The evaluation must be that ‘the length of respiratory-induced motion exceeds 10 mm’.

- For example, if the lengths of motion in the craniocaudal, right-left, and dorsoventral directions are 9 mm, 4 mm, and 4 mm respectively, the three $\sqrt{9^2 + 4^2 + 4^2} = 10.6$ mm

CONTOURING TARGET VOLUMES: GTV

- The measured diameter of tumours is highly dependent on the window width and level chosen to analyze CT slices.
- best concordance between measured and actual diameters and volumes was obtained with the following settings: window width1, 600 and level 600 for parenchyma; window width 400 and level 20 for mediastinum
- Fused and co registered planning PET CT should be used after good experience and confidence within studies. Manual concordance and integration of data on CT and PET is recommended.
- PET CT GTV versus CT based planning (Note atelectasis)
- Do we contour pre or post chemotherapy volumes?

CONTOURING GTV: NODES

- Lymph nodes with a short-axis diameter of 1 cm or with central necrosis are generally considered pathologic, and these should be included in the GTV unless metastases have been excluded by other means, such as mediastinoscopy.

- When mediastinal lymph nodes show no FDG-PET uptake, the probability that they contain metastases is less than 10%, in contrast to CT, for which enlarged nodes may still harbour cancer cells in approximately 25% of cases.

- no evidence to suggest that elective nodal irradiation is indicated in any patient group that receives curative or radical doses of radiotherapy for inoperable NSCLC.

- Selective nodal irradiation on the basis of CT or FDG-PET resulted in less than 5% of isolated nodal failures.

- For the hilar or the mediastinal lymph nodes, the whole anatomic areas that were pathologic before chemotherapy should be included in the GTV, even when a partial or a complete remission was achieved with chemotherapy

GTV-CTV

- Ideally calculate your margins…but Lung cancers are different
- In the absence of prospective trials that compared the recurrence patterns with CTV margins adjusted for histology or size
- GTV to CTV of 5 mm, both for the primary tumour and for the lymph nodes, has been used
- CTV adjustments according to normal tissues may be permitted when there is no evidence for invasion

POST OPERATIVE RT: CTV

CTV consists of:

- the resected involved mediastinal lymph nodes
- Bronchial stump,
- the homolateral hilar node region,
- homolateral lymph node stations 4 and 7.

PLANMING TARGET VOLUME

- In historical series, generic CTV-PTV margins that range from 10 mm to 15 mm
- will depend on the method of immobilization, the assessment of tumour motion, and the methods for on-treatment setup verification/repositioning (eg, cone beam CT [CBCT])
- 4D-CT scans provide internal target volume (ITV) and the position of the tumor at any time in the respiratory cycle can be visualized (timed average treatment)
- When gating and tracking are used, the CTV-PTV margin should take into account the gating window, and dose calculations should be performed on the appropriate breathing phase.

PLANNING RISK VOLUMES

- Contour OARs including Lung, (ipsilateral, bilateral, total); Oesophagus, Heart, Cord, Brachial plexus

- many of the structures at risk are serial organs, including the spinal cord, the main bronchi, and the large blood vessels
- The margin calculations should be based on each institution’s data of setup margins

TREATMENT PLAN IS GENERATED AND DELIVERED

- Dose prescription
- Delivered in a separate lecture

THANK YOU