

## Radiotherapy Treatment of Mobile Lung Tumours: Challenges and New Developments

**M. Josipovic, Copenhagen (DK)**

Lung tumours are subject to respiratory motion and therefore represent a major challenge in radiotherapy, both in the process of imaging and in treatment delivery. The magnitude of tumour motion during normal respiration can vary widely, while tumour motion pattern can be complex and not necessarily regular in time; variations in motion magnitude, frequency and baseline occur within minutes as well as from day to day.

In radiotherapy it is crucial that the shape and position of the tumour within the patient is visualised as exactly as possible. If respiratory motion is not accounted for in the imaging process, the resulting images will be affected by motion artefacts. This will introduce uncertainties in the treatment planning process, which will have an impact throughout the whole course of radiotherapy and may result in underdosing the tumour and/or overdosing the surrounding healthy tissue.

Respiratory tumour motion is also a challenge in the delivery of radiotherapy. A shift in the tumour motion baseline can lead to a risk of tumour being outside the treatment volume. Respiratory motion is often accounted for by adding large treatment margins to ensure that the tumour will always be within the high dose volume. This, however, inevitably results in irradiation of a large volume of healthy tissue.

Several techniques have been developed to manage respiratory motion during computed tomography (CT) image acquisition for radiotherapy planning. The most often used techniques are breath-hold CT, respiratory gated CT and four-dimensional CT. A surrogate is used to generate a respiration signal and therefore it is crucial that the patients are able to breathe very regularly or hold their breath at a certain predefined level. The quality of acquired CT images can be degraded by large residual tumour motion and by non-stable correlation between the respiration signal and the tumour motion. Effective respiratory guidance is therefore necessary for patient compliance.

PET images are also affected by motion artefacts, quantitative parameters are underestimated while the apparent tumour volume tends to be overestimated. If the patient respiratory pattern is irregular, the lesions appear in slightly different positions on PET and CT images. Two general approaches of respiratory motion management are applied in PET imaging: elimination of motion by acquiring images in one single breathing phase and capturing the tumour in all phases of the breathing cycle. As with CT scanning, the PET imaging procedure relies on translating the patient's breathing pattern into a trigger signal for image acquisition.

A new paradigm, called "dose-painting" is now gaining interest in radiotherapy: using the metabolic information provided by the PET images, the tumour could be "painted" so that volumes of high tracer uptake receive a higher radiation dose. However, for this approach to be clinically viable, blurring-free images are essential to precisely define which sub-volumes of the PET-positive tumour would benefit from a higher dose.

In conclusion, in order to reduce the uncertainties in the treatment of mobile lung tumours, their motion must be taken into account – during imaging as well as during radiotherapy delivery. Respiratory motion management in imaging for radiotherapy can improve the accuracy of tumour volume definition and of quantification in PET images. More research is needed to address issues of remaining image artefacts and how to handle irregular breathing patterns. Respiratory motion management of PET/CT will likely play a key role in the adoption of new treatment paradigms.

Oct.29

## References

1. Keall PJ, Mageras GS, Balter JM, Emery RS, Forster KM, Jiang SB, Kapatoes JM, Low DA, Murphy MJ, Murray BR, Ramsey CR, Van Herk MB, Vedam SS, Wong JW, Yorke E 2006 The management of respiratory motion in radiation oncology report of AAPM Task Group 76. *Med Phys* 33:3874-3900.
2. De Ruysscher D, Nestle U, Jeraj R, Macmanus M 2012 PET scans in radiotherapy planning of lung cancer. *Lung Cancer* 75:141-145.
3. Nehmeh SA, Erdi YE, Meirelles GS, Squire O, Larson SM, Humm JL, Schoder H 2007 Deep-inspiration breath-hold PET/CT of the thorax. *J Nucl Med* 48:22-26.
4. Bettinardi V, Picchio M, Di MN, Gianolli L, Gilardi MC, Messa C 2010 Detection and compensation of organ/lesion motion using 4D-PET/CT respiratory gated acquisition techniques. *Radiother Oncol* 96:311-316.

Oct.29