Purpose: Radiobiologically adaptive radiation therapy (RT) has not been used, largely, because the patient/tumor/organ specific radiobiological parameters are difficult to obtain. We introduce a method to extract such parameters for lung cancer based on the PET/CT data acquired before and during RT.

Methods: Changes in lung tumor volume measured from PET/CT data acquired before and during RT were analyzed by a two-component model, assuming that lung tumor cells comprise both radiosensitive and radioresistant components. This model consists of 4 major parameters: radiosensitivity parameter as, potential doubling time for the radiosensitive cells Tp, initial fraction of radioresistant cells h, and the disintegration half-life of radiation-damaged cells (Td). The parameter h can be determined using the pre-treatment PET with Fluoromisonidazoles. The tumor volume change measured with PET provides a strong constraint to as and Tp because it does not depend on the disintegration process. The model was used to determine the patient specific radiobiologically optimal dose and fractionation for the remaining part of RT using the model parameters determined for the patient. The method was tested using the data from 6 lung cancer patients.

Results: Significant variations of the model parameters were found between patients. For example, for the patient data studied, as varies between 0.031 to 0.091 Gy^-1, the potential doubling time changes from 14 to 26 days and Td varied from 3.6 and 90 days. The calculated optimal doses and/or fractionations for the remaining part of RT based on the patient specific model parameters are also patient specific, varying by 50% for the data considered.

Conclusions: The change in lung tumor volume observed from PET/CT in the early part of RT provides a means to probe radiobiological properties of the tumor, allowing the delivery of individualized, radiobiologically adaptive RT in the remaining course of the treatment.