Purpose: To perform adaptive radiation therapy treatments for lung cancer using IMRT; to show that adjusting the target dose after each fraction, in order to 'react' to errors in the dose delivered in prior fractions, can lead to significant changes in the daily tumor dose over the treatment.

Method and Materials: Before the start of treatment, the beamlet intensities are optimized to deliver the current target dose distribution for a target set of breathing patterns at minimal healthy tissue dose. In each fraction, the current beamlet intensities are delivered, and the patient's breathing pattern is measured. The breathing pattern set is updated using the breathing pattern, and the target dose distribution is updated to account for dose errors realized in the previous fraction. The beamlet intensities are then re-optimized for the updated dose distribution and uncertainty set, to be used in the next fraction. This process continues until the end of the treatment. We consider three types of updates to the target dose distribution: the reactive± update, which responds to both under and overdose; the reactive- update, which responds only to underdose; and the reactive+ update, which responds only to overdose.

Results: On breathing pattern sequences obtained from real patients, dose-reactive methods result in final dose performance comparable to non-dose-reactive methods. However, as the treatment progresses, the reactive± update results in growing daily underdose and overdose, the reactive- update results in growing daily overdose, and the reactive+ update results in growing daily underdose. In contrast, non-reactive methods have stable or decreasing tumor underdose and overdose.

Conclusions: By incorporating dose-reaction, the final tumor dose distribution can be made to conform closely to the target dose distribution, but at the cost of increasing tumor underdose and/or overdose. This increasing heterogeneity may have implications for the biological effectiveness of treatments obtained by dose-reaction.