Purpose: To quantify the relationship between the post-treatment [18F]-2-fluoro-2-deoxyglucose (18F-FDG) positron emission tomography (PET) uptake and radiation dose received and correlate this relationship with prospectively scored pulmonary radiation toxicity.

Methods: 34 patients treated for esophageal cancer with thoracic radiotherapy were evaluated prospectively at the MD Anderson Cancer Center. The treatment planning computed tomography (CT) imaging was registered with the restaging PET/CT. Using histogram analysis, the voxel average FDG-PET uptake vs. radiation dose was obtained for each case and linear regression was performed. The slope of the linear regression was termed the pulmonary metabolic response rate (PMRR). Common Toxicity Criteria version 4 was used to score pneumonitis. Exhaled nitric oxide (eNO) was measured on the first and last days of radiation treatment. Receiver operating characteristic curves were used to determine the threshold PMRR, mean lung dose, volume of lung receiving 5, 10, 20 and 30 Gy and eNO ratio (End/beginning) that can best predict symptomatic patients.

Results: 29 patients were evaluable. The median of the mean standard uptake value from lung that received 0–5 Gy was 0.51 (range, 0.34–1.24), 5–10 Gy was 0.71 (range, 0.39–1.32), 10 –20 Gy was 0.78 (0.40–1.56), and > 20 Gy was 1.10 (range, 0.43–3.01). 25 patients had grade 0 or 1 pulmonary symptom score and 4 patients had grade 2 or higher (symptomatic) score. Both PMRR and the eNO ratio gave a significant area under the curve of 0.86 ($p = 0.02$) and 1 ($p<0.001$) respectively. Using a PMRR threshold of 0.0184 yielded a true positive rate of 0.75 and false positive rate of 0.125.

Conclusions: In this prospective study, the PMRR predicted for development of radiation pneumonitis. This unique quantitative assessment of radiation pnuemonitis can be used for quality control to deliver higher doses of radiation safely.