Purpose:
Rectum is the main dose-limiting organ in radiotherapy (RT) of prostate cancer (PC). This organ displays considerable motion leading to uncertainties in the rectum dose-volume histogram (DVH), which is likely to also influence the associations between rectal DVHs and toxicity. The aim of this study was to improve the understanding of how rectum motion influences these associations by introducing and applying a rectum motion model to generate ‘motion-inclusive’ DVHs.

Methods:
Varying amounts of random and systematic organ motion (“shifts”) were generated by altering the standard deviations (SDs) of normal distribution from 0.1 cm to 1 cm in steps of 0.1 cm. In order to simulate random shifts, we perturbed each dose fraction with a unique value of shift drawn from a normal distribution whose SD was proportional to the simulated random shift. The systematic shift was simulated similarly but with a normally distributed shift that remained constant over the entire course of trial. The delivered DVHs (dDVHs) were generated as a number of pseudo DVHs. The dDVHs were associated with prospectively registered late rectal larger than Grade 2 RTOG toxicity (dichotomized; minimum 5 year follow-up) for a cohort of 232 PC patients treated using 35 dose fractions and compared to the planned rectum DVH (pDVH). The Spearman’s rank correlation coefficient (Rs) was used as a measure of the associations.

Results:
Systematic errors reduced the association at rectum volumes receiving doses above 40 Gy (V40) and doses less than the dose max. The Rs (V40) was insensitive to the magnitude of systematic and random errors. Random errors smoothed out the curve describing Rs vs. Vx.

Conclusions:
A model for simulating rectal motion has been presented and the corresponding DVHs investigated in relation to rectal toxicity. Systematic errors reduced the association above V40 and doses less than the dose max.