Purpose: The objective of this study is to optimize a retrospective respiratory-gated micro-CT protocol for free-breathing rats to maintain image quality while reducing scan time and x-ray dose.

Methods: Five male Sprague-Dawley rats were anaesthetized with ketamine and xylazine. Micro-CT images were acquired with a GE Locus Ultra scanner at 80 kVp, 50 mA, 10 gantry-rotations, with a scan time of 50 s and 0.28 Gy entrance dose. The respiratory traces of the free-breathing rats were recorded throughout the scans and used to retrospectively sort the projection views that were acquired during peak inspiration and end expiration. 3D images were reconstructed with an isotropic voxel spacing of 0.15 mm. To assess the impact of missing projection views, we reconstructed images using all 10 gantry-rotations and progressively fewer rotations (down to 3). We reconstructed a second set of images where the missing views were filled with the projection that was closest to the desired phase. Image-based analysis of the image noise and missing view artefacts were indicators of the image quality. The physiological data (lung volume, CT density, functional residual capacity and tidal volume) were also computed.

Results: By adding nearly in-phase projections, the missing view artefacts were completely eliminated and the image noise was reduced. Measured values of lung volume, lung density and airway volume were stable for 5 or more gantry-rotations. Filling the projections using nearly in-phase views resulted in lower measured values for tidal volume (1.26 mL 0.22 mL in-phase, 0.89 0.17 mL nearly in-phase).

Conclusions: A 25 s imaging protocol would provide adequate physiological measurements at both respiratory phases for in-phase reconstructions with reduced image quality. An image containing 50% of in-phase views (remaining views are nearly in-phase) is required to measure lung volume, 90% for airway volume and >65% for tidal volume.