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In-vivo study of lung physiology with sub-second X-ray tomographic microscopy

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Lung failure represents the leading cause of morbidity and mortality worldwide and is the fourth leading cause of death in Switzerland [1,2]. Despite the fact that recent decades have brought forth a huge clinical progress in treating lung injuries, including e.g. the immediate postnatal treatment of very preterm infants, two hypotheses on the structural alterations in the gas-exchange area during breathing are still under debate: a heterogeneous distention pattern of different lung areas and a homogeneous cyclic opening-and-collapse of all alveoli. Current techniques for performing lung imaging with small animal models at synchrotrons [3,4], however, were unsuccessful in answering these questions either by only applying 2D imaging or due to insufficient temporal and/or spatial resolution.

We present our recently developed protocol for 3D in-vivo lung imaging, realized by a new ultra-fast endstation with a novel data acquisition and post-processing paradigm [6]. Results from pilot experiments conducted at the TOMCAT beamline with ex-vivo mouse samples, where tomograms are acquired only in the fraction of a second, are presented. We describe our approach to image formation and biological interpretation therein, aiming at optimal image quality in terms of contrast, resolution and deposited radiation dose. Finally, the first biological application of the technique is demonstrated, namely the study of tissue overextension in ventilated lungs as a possible cause to various lung disfunctions such as the ventilator-induced lung injury (VILI).

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