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X-RAY SPECKS: SEEING THE LUNGS IN A NEW LIGHT

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Before a baby is born, its lungs are filled with the same amniotic fluid that it floats in during pregnancy. The fluid provides nutrition, protection and absorbed oxygen. At birth, this fluid must be cleared rapidly from the lungs before the newborn can begin to breathe gaseous oxygen. These first minutes are critical to the baby's survival but, because the lungs are so delicate and of such low density, they are among the most difficult organs to image (Fouras et al. 2009). As a result, until now, we have known very little about what happens and why things sometimes go wrong (Hooper et al. 2009).

Recent major advances in X-ray imaging, using "phase contrast" techniques, have made it possible to see even the smallest airways of the lung in a single image (Kitchen et al. 2004; Hooper et al. 2007). Phase contrast radiography has enabled us to witness mammalian lungs aerating at birth with unprecedented clarity (Figure 1) and has fundamentally changed our understanding of how the lungs become functional organs for gas exchange.

Our team of physiologists, physicists, clinicians and engineers have employed these advances in imaging technology to quantify the structure and function of the lungs of newborn animals to assess how efficacy of current resuscitation strategies for reviving infants at birth. However, measuring regional lung air volumes normally requires the lungs to be imaged in three dimensions (3D) using computed tomography (CT), which cannot be performed fast enough to image the first breaths in real time. Knowledge of the underlying physics of phase contrast imaging has enabled us to measure regional lung air volumes from two-dimensional (2D) images to an accuracy of a few micro litres (Kitchen et al. 2008; Kitchen et al. 2011).

Both quantitative and qualitative image analysis have changed long held ideals about the cardiopulmonary physiology of the neonate and the transition to air breathing at birth. We have been able to quantify how uniformly, and hence how safely, the delicate newborn lungs aerate using various ventilation/resuscitation techniques employed in the clinic. Imaging has revealed the inadequacies of some resuscitation strategies whilst demonstrating significant benefits of others. As a result, the international guidelines for resuscitating newborns have recently been updated to reflect these findings (Perlman et al. 2010). Our image-based data that reveal how best to ventilate newborns is now being used to train clinicians and emergency workers around the world.

In related works, we have shown that phase contrast can provide much more information about the structure of the lungs than conventional absorption-based radiography. We are exploiting these benefits to yield greater outcomes for diagnostic imaging and to reduce the dose of ionizing radiation to the subject. The long term goal is to see these techniques directly implemented in the clinic for diagnostic imaging applications.

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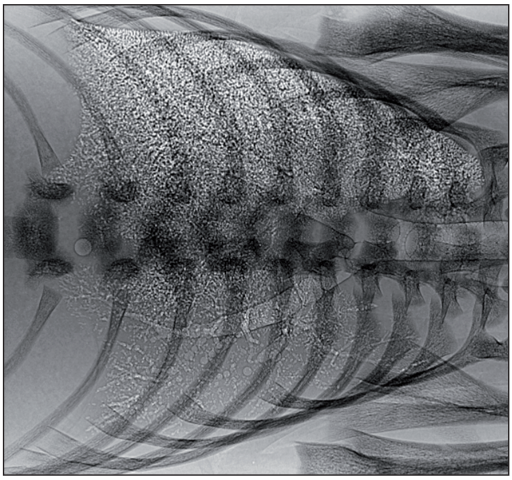

Figure 1. Phase contrast X-ray image of the partially aerated lungs of a newborn rabbit imaged lying on its side at the SPring-8 synchrotron, Japan. The effects of gravity dictate how uniformly the lungs aerate.

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