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Phase contrast X-ray imaging of the lung at birth

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The transition to newborn life after birth represents one of life's greatest of challenges, yet for most of us we pass through this phase of our lives with only a brief cry that is greeted with much relief and joy by our expectant parents. Nevertheless, even in developed countries like Australia, we are much more likely to die on the day we are born than on any other day of our lives, until we reach the grand old age of 110. This simply reflects the extent and complexity of the physiological changes that must occur for the newborn to survive after birth. At birth, the airways are liquid-filled and so the lungs must aerate before they can become the sole organ of gas exchange and the resistance to blood flow through lungs must dramatically decrease. The latter enables the lungs to accept 100% of right ventricular output and allows the two circulations (pulmonary and systemic) to separate. As a result, the pulmonary circulation can work at a much lower pressure than the systemic (15 vs 100 mmHg), which is vital for respiratory function after birth. Lung aeration is not only vital for establishing the onset of pulmonary gas exchange, but is also vital for triggering the decrease in pulmonary vascular resistance, which in turn triggers the circulatory changes required for survival after birth. However, until recently, our understanding of the mechanisms controlling airway liquid clearance (=lung aeration) were restricted to an osmotic process that is slow and cannot account for lung aeration in premature infants. This lack of understanding greatly limited the clinical options available to assist infants who are unable to aerate their lungs at birth and therefore require assistance.

The ability of phase contrast X-ray imaging to visualise air liquid interfaces has greatly advanced our understanding of lung aeration at birth, enabling us to identify the mechanisms involved and to investigate treatments that can be used to facilitate this process. Visualising lung aeration in real time allowed us to demonstrate that transpulmonary pressure gradients, however they are applied, regulates the rapid movement of water out of the airways and into the surrounding tissue from where it is cleared. Discovering this mechanism allowed us to devise strategies that can be used to facilitate this process, which have been adopted into clinical practice. In addition, when combined with angiography, we were able to define the spatial and temporal relationship between lung aeration and the increase in pulmonary blood flow after birth. As a result, we identified a major mechanism responsible for the increase in pulmonary blood flow that was previously undescribed. More recently, we have used phase contrast X-ray imaging to investigate laryngeal function in the newborn and a rapid computed tomography approach to track lung liquid as it leaves the airways after birth.

In summary, the unique properties of synchrotron generated X-rays have allowed us solve many of the questions surrounding how we make the transition to new born life. For the last 50 years or more we have either had no idea or mistakenly thought other mechanisms controlled these vital processes, which has greatly limited our capacity to intervene and assist infants at birth. However, with our new understanding we are making good progress in improving the outcomes for all newborn infants that require assistance at birth.

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