Using PIV to Quantify the Therapeutic Mechanisms of Nasal Cannula Therapy in New-borns

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ABSTRACT

It is common for premature babies to require breathing support. If the baby is able to breathe spontaneously, a High Flow Nasal Cannula (HFNC) may be used. HFNC is becoming a preferred method of oxygen delivery for babies as it is more comfortable than other therapies (such as CPAP which requires a facial mask), has a lower risk of airway trauma, allows parental interaction (holding), allows easier feeding and provides a mild lung pressure at the end of expiration. Since HFNC is a young therapy (established ~2000) its primary mechanisms of action, have until recently, been poorly understood. It is suggested [1] that there are five mechanisms behind the efficacy of NHF, which include nasopharyngeal dead space washout, reduced work of breathing, improved lung compliance, reduced metabolic cost of gas conditioning, and the provision of distending pressure. There has been some experimental investigation performed on NHF in adults [2], but few studies have been performed on neonates. Since the new-born and adult airway anatomy differ significantly, it is expected that contribution of the mechanisms of action are of different magnitudes. Key differences of the neonate's anatomy (which influence their breathing flow field) include underdeveloped turbinate's, a long thin epiglottis and a large tongue which almost entirely occupies the oral cavity.

To quantify the mechanisms of therapeutic efficacy two experimental methods are used. Stereo Particle Image Velocimetry (SPIV) experiments will be used to determine a 3D ensemble averaged velocity field within the airway. SPIV will be performed on a scaled transparent silicon flow phantom which is connected to a flow circuit providing realistic respiratory flows. Subsequent experiments with a capnograph will measure carbon dioxide concentrations at various locations throughout the airway. Comparisons between natural breathing and HFNC assisted breathing are anticipated to reveal how HFNC interacts with new-borns.

1. Dysart, K., Miller, T. L., Wolfson, M. R., & Shaffer, T. H. (2009). Research in high flow therapy: mechanisms of action. *Respiratory Medicine*, 103(10), 1400-1405.
2. Spence C.J.T., Buchmann N.A., Jermy M.C., & Moore S.M. (2010) Stereoscopic PIV measurements of flow in the nasal cavity with high flow therapy. Experiments in Fluids:1-13 DOI 10.1007/s00348-010-0984-z.