**Proceedings of the Canadian Society for Mechanical Engineering International Congress**
**32nd Annual Conference of the Computational Fluid Dynamics Society of Canada**
**Canadian Society of Rheology Symposium**
**CSME-CFDSC-CSR 2025**
**May 25–28, 2025, Montréal, Québec, Canada**

# Regulation of perflubron volume in lung during total liquid ventilation based on the detection of pressure drops

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## ABSTRACT

Each year, around 400 Québec births are considered as extreme preterm. Total liquid ventilation (TLV), using perflubron, may be an alternative to the conventional ventilation, too often insufficient and/or harmful, for some of the most extreme preterm. Inolivent research group develops a TLV technology which controls insufflation and drainage of the breathable liquid in newborn flexible airways. The forced expiratory flow may provoke a pressure drop measured at the endotracheal tube. It is assumed to be occasioned by an upstream flow limitation, a chocked flow in the airways generating a collapsus. To prevent it, end expiratory liquid volume (EELqV) must remain greater than a critical threshold. Conversely, an excess in EELqV might create a deleterious overdistension of the lungs. The main goal was to minimize the EELqV while keeping it above the critical value triggering the tracheal collapse. The method was based on:

1/ The real-time detection of airways collapsus thanks to a dynamic model of pressure estimation, compared with measured pressure. In the absence of collapsus, the model error must be located between +/- 5 $cmH_2O$. A pressure error lower than a detection threshold (-5 $cm.H_20$) implies a correction.

2/ Inspired volume of breathable liquid is based on systematic research of a pressure drop error model, in emptying progressively the lung with a drift of -0.4 mL/kg/cycle. Once the algorithm detects a pressure drop beyond half of the expiratory time, insufflated perflubron volume is increased by 0.9 mL/kg at the next cycle.

The strategy was implemented on the Inolivent-10 prototype and experienced on a 2.3 kg piglet under general anesthesia, during 1h13, with CT image capture at the beginning and end of sequence. These latter have been segmented and analyzed with 3D Slicer and allowed to harvest the lung volume.

On 306 cycles, 92 include a correction. One may observe a trend of 5 cycles of progressive decrease, removing 2.2 mL/kg of volume in the lungs, followed by 2 cycles with correction, adding 2.2 mL/kg. At the end, the lung volume is about 47.8 mL/kg against 39.1 mL/kg at the beginning, so an increase of 8.7 mL/kg.

This first experiment demonstrates the feasibility of automatically seeking and regulating the EELqV during TLV. Upcoming works will must consider machine learning to improve the detection performances lung volume regulation. This control represents a new step for long-term TLV in intensive care units.