A novel active neonatal pulmonary simulator for high-fidelity training in mechanical ventilation*

I. Baldoli, S. Tognarelli, F. Cecchi, A. Menciassi and C. Laschi

Abstract—The present study proposes an innovative multi-compartmental infant respirator simulator developed to reproduce different infants' physio-pathologic conditions, in order to simulate widely differing kinds of clinical scenarios that neonatologists may face during mechanical ventilation assistance.

I. INTRODUCTION

Mechanical ventilation is the principal therapeutic intervention for newborns affected by severe lung diseases, however the outcome of the methodology is affected by the risk of complications and unexpected side effects [1]. Given the complexity of this field, a specific program of Continuing Medical Education (CME) is necessary to train nurses and neonatologists in order to guarantee adequate practical knowledge and experience. Simulation strategy is the most effective means to reach the aim, but current devices for neonatal mechanical ventilation training, both on the market and in the research field, are still inadequate for high fidelity representation of realistic clinical scenarios. The present study arises from the necessity of an innovative and versatile neonatal respiratory simulator designed for being compatible with mechanical ventilators commonly used in NICUs and potentially useful in training courses for physicians and nurses [2]; to obtain a high-fidelity representation of physiological pulmonary features and breathing patterns of infants, the prototype is based on a multi-compartmental model.

II. MATERIALS AND METHODS

The neonatal simulator is composed of five chambers with variable volume (Fig. 1), that are 50 ml glass syringes disposed to reproduce the physiological lobes distribution and modified for the connection to the conductive network (a net of plastic tubes sized to reproduce the airway tree of infants). Each plunger of the five syringes is mounted in-built with the rod of a DC linear motor (Faulhaber Linear DC servomotor LM2070-080-01) that can be driven through a dedicated software interface.

This mechanical solution allows to regulate the volume within each chamber in order to replicate the respiratory cycle with the inspiratory and expiratory phases. Pressure information within each lobe is obtained thanks to pressure sensors (MS147105GT, Measurement Specialties), fixed on the top of each plunger. Pressure and volume trends are related on the basis of the compliance level set by the operator, while flux is obtained as time derivative of volume. Compliance value can be independently defined for each chamber and it can be modified by software during simulation. Finally, a custom LabVIEW software was developed to manage the prototype functioning.

![Figure 1. Schematic representation of the neonatal respiratory simulator.](image)

III. RESULTS

The neonatal pulmonary simulator presented in the study allows to replicate and evaluate every mechanical ventilation modality in case of infants with widely differing kinds of respiratory physio-pathologic conditions. From the analysis of the detected measurements and considering the system behavior, the prototype permits to choose the best ventilation strategy and to practice a more conscious management of ventilation parameters; the training with the simulator also promote a deepen knowledge about physiologic measurements involved in respiration, thanks to the dedicated scenarios with alarms and warning messages.

REFERENCES


---

*This work was partially supported by MERESSINA Project, grant “Sviluppo e ricerca sulle metodologie innovative nella formazione continua – anno 2011” (Grant n. – Codice gara: 453869. Approval number for funding – Codice CIG: 4415895FD1) and in part by CureToy EU Project (Project Reference: 287932; Seventh Framework Programme, research area: ICT-2011-7).

I. Baldoli, S. Tognarelli, F. Cecchi, A. Menciassi and C. Laschi are with the BioRobotics Institute of the Scuola Superiore Sant’Anna, V.le Praggio, 34, 56025 Pontedera (PI), Italy (corresponding author e-mail: i.baldoli@sussup.it).