The University of Nottingham

WARWICK
THE UNIVERSITY OF WARWICK

Investigation of Closed-loop Ventilation Strategies for Neonatal ICU Patients Using Computational Simulation

Closed-loop ventilation

Headline aims:

- Compensate for the shortage of clinicians in ICU
  - Clinicians' workload directly linked to the patients outcome
  - Number of patients undergoing MV considerably increasing
  - Reduce number of bedside visits by clinicians
- Decrease the risk of human errors
- Improve personalisation of therapy
- Decrease the cost of prolonged MV days

It seems that the current approaches have not earned the required reliability and credibility in the field yet, more likely due to the sensitive nature of its application in ICU.

Initial projects aims

- Ethical approval & collecting data
- Adapting the simulator for neonatal patients
- Matching the simulator to patient data
- Creating & evaluating virtual patients
- Designing a controller
- Implementing the closed-loop system for virtual patients

Progress to date

Data collected for the study:

- So far, we have collected data from 5 patients

	Weight (g)	F_IO_2	RR (bpm)	V_T (mL kg^{-1})	PEEP (cmH_2O)	pH	PO_2 (kPa)*	PCO_2 (kPa)*	PIP (cmH_2O)	mPaw (cmH_2O)
PID#1	975	0.21	45	3.1	5.1	7.28	4.43 (v)	7.5 (v)	21	9.3
PID#2	1080	0.45	60	5.2	6	7.16	6.91 (v)	7.97 (v)	28	13
PID#3	1575	0.21	40	4.2	5	7.49	4.68 (c)	5.5 (c)	11	6.2
PID#4	1830	0.21	50	5.5	5	7.2	4.13 (c)	6.77 (c)	15	7
PID#5	1830	0.21	40	6.1	5	7.35	6.12 (c)	5.25 (c)	18	7.3

* (a) arterial; (v) venous; (c) capillary

Progress to date

Problems encountered

- Ethical approval
- Collecting data for $P_{a/v}O_2$ and $P_{a/v}CO_2$ is challenging in neonatal patients:
  - What data we collect/need in order to make a virtual patient

Patient	Ventilator
Age; **Weight**; **$P_{a/v}O_2$**; **$P_{a/v}CO_2$**; **PIP/mPaw**; $P_E'CO_2$; PVR; CO; Hb; VO_2; R_{aw}; V_{frc}; SaO_2; $pH_{a/v}$; BE	**PEEP**; **V_T/Ventilator pressure**; **RR**; **F_IO_2**; DC; RQ; EET

- 3 out of 5 patients only have partial pressure of capillary blood gases rather than venous/arterial blood. So they cannot be used when tuning the simulator.

Progress to date

- Preliminary results:

Ventilator Settings				Blood Gases & Airway Pressures							
F_IO_2	RR bpm	V_T mL kg^{-1}	PEEP cmH_2O	P_vO_2 (kPa)		P_vCO_2 (kPa)		PIP (cmH_2O)		mPaw (cmH_2O)	
				Data	Model	Data	Model	Data	Model	Data	Model
0.21	45	3.1	5.1	4.43	4.3	7.5	7.4	21	21	9.3	9

Next steps/challenges

- More data with arterial/venous blood gasses
- Implementing disturbance(s)
- Feedback parameters
- Lung-protective ventilation
- Designing a robust controller