Factors associated with asynchronies in Pressure Support Ventilation (PSV): a bench study

Dott. ERIC ARISI (1), Dott.ssa ROBERTA PUCE (2), Dott.ssa MARTINA PAGLINO (1), Dott.ssa ISABELLA BIANCHI (1), Dott. ANDREA BORROMINI (1), Dott.ssa ANITA ORLANDO (1)(2), Dott. MARCO POZZI (2), Prof. GIORGIO ANTONIO IOTTI (1)(2), Prof. FRANCESCO MOJOLI (1)(2)

(1) Anesthesia, Intensive Care and Pain Therapy, University of Pavia, Viale Camillo Golgi, 19, Pavia, Italia.
(2) Anesthesia and Intensive Care, Fondazione IRCCS Policlinico S. Matteo, Viale Camillo Golgi, 19, Pavia, Italia.

Argomento: Insufficienza respiratoria acuta e ventilazione meccanica

Introduction: aim of this study was to evaluate how respiratory mechanics, muscle efforts, respiratory rates and pressure support levels affect patient-ventilator interaction in pressure support ventilation (PSV) in a simulated patient.

Methods: We tested 5 ventilators (IMT Medical Bellavista 1000, Hamilton Medical G5 and C6, Mindray SV300, Philips V200) using default trigger settings (Inspiratory Trigger Sensitivity (ITS) 2 l/min, Expiratory Trigger Sensitivity (ETS) 25%, default Ramp) and the available "advanced" waveform-guided trigger. A IngMar Medical ASL 5000 Breathing Simulator (Software Version 3.6) simulated 3 lung mechanics:normal (Compliance (C) 60 ml/cmH_2O, airway resistance (R) 10 cm$H_2$0/l/s), obstructive (C 90, R 20) and restrictive (C 25, R 10). We tested two respiratory rates (RR 15 and 30/min), 3 levels of muscle effort (Pmusc -3, -6 and -12cmH_2O) and two pressure supports (PS 10 and 20cmH_2O). Thus we tested 72 conditions with each ventilator. All data and waveforms were recorded by ASL 5000 software and analysed with MedCalc (version 18.11 MedCalc Software). From ASL data we obtained Trigger Delay (TD), Cycling Delay (CD), percentages of TD and CD above 300ms, of Early Cycling (EC) above 100ms, of Auto Triggers (AT), Ineffective Efforts (IE) and Double Triggers (DT). ANOVA and paired t-test were used when appropriate.

Results: Results are shown in Table 1 (standard trigger) and 2 (automatic trigger) as mean ± SD. In all conditions we found no DT.

Conclusion Compared to normal lung mechanic, the obstructive had more, and the restrictive less, asynchronies, although EC were higher in the restrictive. Weaker effort, higher RR and PS were associated with increased asynchronies. Lung mechanics and weak muscle are the major factors associated with asynchronies with waveform-guided triggers, less affected by changes in RR and PS.

Table 1

Standard Trigger	TD (ms)	CD (ms)	TD >300ms (%)	CD >300ms (%)	EC >100ms (%)	IE %	AT %
	Mean ± St Dev	Mean ± St Dev					
RESTRICTIVE	85,6 ± 39,4 *	89,5 ± 75,4	0	1,6 ± 12,7 *	18,9 ± 37,3 *	0 *	0,1 ± 0,7
NORMAL	155,5 ± 68 *	329,4 ± 305,9	5,4 ± 16,2	35,8 ± 47,4 *	0	12,4 ± 21,2 *	0,1 ± 0,7
OBSTRUCTIVE	266,2 ± 96,3 *	1196,1 ± 827,6 *	32,5 ± 40,3 *	73,9 ± 42,8 *	0	37,5 ± 30,4 *	0,2 ± 1,0
Pmus -3cmH_2O	213,5 ± 108,1 *	967,7 ± 844,3 *	17,9 ± 31,9	57,7 ± 49,2	8,7 ± 27.4	29,5 ± 30,9	0,4 ± 1,4
Pmus -6cmH_2O	162,7 ± 97,1	603,5 ± 678,1 *	13,1 ± 29,4	40,6 ± 48,8	9,1 ± 27,6	17,6 ± 25,9	0
Pmus -12cmH_2O	131,2 ± 87,7	219,2 ± 345,1 *	6,9 ± 23,6	13 ± 32,6 *	1,2 ± 9,0	2,8 ± 10,9 *	0
FR 15 bpm	167,2 ± 119	504,6 ± 827,7	12,7 ± 29,8	27,1 ± 43,8	12,6 ± 31,7	8,6 ± 19,3	0,3 ± 1,2
FR 30 bpm	171,1 ± 85,2	641,5 ± 802,5 *	12,6 ± 27,8	47 ± 49,5 *	0 *	24,7 ± 30,0 *	0 ± 0,2
PS 10cmH_20	150,7 ± 83,6	423,6 ± 590,6	6,9 ± 21,3	25,7 ± 43,2	6,1 ± 22,9	11,9 ± 23,5	0,2 ± 0,9
PS 20cmH_2O	187,5 ± 117,3 *	794,8 ± 795,2 *	18,3 ± 33,8 *	48,4 ± 49,4 *	6,5 ± 23,5	21,3 ± 28,4 *	0,1 ± 0,6
Data in the same box marked with * show a statistically significant difference (p<0,01)							

Table 2

Waveform-Trigger	TD (ms)	CD (ms)	TD >300ms (%)	CD >300ms (%)	EC >100ms (%)	IE (%)	AT (%)
	Mean ± St Dev	Mean ± St Dev					
RESTRICTIVE	81,2 ± 34,3 *	84,5 ± 62,1	0 ± 0,3	0	30,2 ± 44,1 *	0 ± 0,3	0,1 ± 0,7
NORMAL	136,9 ± 70,5 *	273,4 ± 273,3	4,4 ± 14,9	10,6 ± 27,1	7,6 ± 24,7	5,4 ± 14,3	0
OBSTRUCTIVE	225,6 ± 99,3 *	729,4 ± 1059,2 *	21,9 ± 29,6 *	35,3 ± 44,2 *	0,1 ± 0,5	22,1 ± 27,6*	0,1 ± 0,4
Pmus -3cmH_2O	198,3 ± 88,8 *	546,9 ± 834,9	15,6 ± 26,1 *	31,7 ± 41,9*	12,3 ± 31,0	18,7 ± 26,1 *	0,2 ± 0,8
Pmus -6cmH_2O	145,9 ± 96,8 *	408,3 ± 812,5	9,4 ± 23,1	9,3 ± 28,3	12,7 ± 32,1	7 ± 18,2	0
Pmus -12cmH_2O	99,5 ± 67,7 *	186,7 ± 460,9	1,3 ± 7,8*	4,8 ± 19,3	12,9 ± 32,7	1,2 ± 8,8	0
FR 15 bpm	150,4 ± 106,9	369,1 ± 760,8	10,9 ± 24,9	14,8 ± 33,6	25,2 ± 41,3	5,4 ± 15,3	0,1 ± 0,6
FR 30 bpm	145,4 ± 79,5	434,1 ± 756,1	6,8 ± 16,7	15,8 ± 33,1	0 ± 0,3 *	12,9 ± 23,6 *	0 ± 0,4
PS 10cmH_20	143,6 ± 94,7	365,1 ± 656,9	8,6 ± 20,5	17,1 ± 34,4	7,7 ± 26,2	7,6 ± 18,5	0,1 ± 0,5
PS 20cmH_2O	152,2 ± 93,7	393,7 ± 812,3	9 ± 22,2	13,5 ± 32,2	17,6 ± 35,9 *	10,8 ± 21,7 *	0,1 ± 0,4
Data in the same box marked with * show a statistically significant difference (p<0,01)							