

Poster Corner 1 - Advanced monitoring during mechanical ventilation

007 Capnography as a possible predictor of intraoperative shock severity

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INTRODUCTION. Capnography is an indispensable tool for intraoperative respiratory monitoring. At the same time it can be used to diagnose systemic hypoperfusion associated with shock.

OBJECTIVES. Our study aimed at testing the hypothesis that capnography could help predict severity of intraoperative shock.

METHODS. Since 2017 patients undergoing surgery at the Department of Abdominal Surgery of Ivano-Frankivsk Regional Clinical Hospital (Ukraine) have been under investigation. So far 12 patients (8 male, 4 female) within age range 28-65 y.o. have been recruited. 10 of them intraoperatively developed hemorrhagic shock and 2 - distributive shock. The indirect blood pressure (BP) and end-tidal CO₂ (PETCO₂) were continuously monitored during surgery. The obtained dynamics and correlation of the mentioned values in the phase of shock formation and treatment were later analyzed. This is an ongoing study, only preliminary results are presented.

RESULTS. PETCO₂ decreased by 1 mmHg with systolic BP going down by 6-8 mmHg (systolic BP range 120 to 50 mmHg). Decrease of PETCO₂ to 18-22 mmHg, in spite of fluid therapy, indicated the need for vasopressors. Decrease of PETCO₂ to 17 mmHg posed a risk of circulation cessation and called for highest possible infusion rate of crystalloid solution and bolus dose of epinephrine. Adequate treatment resulted in PETCO₂ increase which itself is a more reliable marker of stable condition than BP.

CONCLUSIONS.

1. In severe shock patients indirect measurement of blood pressure is impossible / inaccurate, unlike PETCO₂ control, which allows for continuous and reliable evaluation of blood circulation.
2. The increase in the level of PETCO₂ is a marker of adequacy of fluid therapy.
3. Stabilisation and more effective increase of PETCO₂ positively correlated with the use of crystalloid solutions, which justified their use in critical conditions due to comparatively higher infusion rate aimed at maintaining the preload and preventing cessation of circulation.

008 Respiratory mechanics with elastance derived calculation of relative end inspiratory using a simulator of artificial ventilation (SimVA), comparison between real and virtual acute respiratory distress syndrome patients

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INTRODUCTION. Simulation in intensive care is an innovative method for teaching. Respiratory settings are responsible for some morbi-mortality of our patient. For this reason we develop a simulator of artificial ventilation (SimVA) and virtual ARDS patients. Mathematical model resolved differential equations of chest and lung movements in order to match with a clinical ARDS data base. Transpulmonary pressure has been shown to improve oxygenation and avoid ECMO in ARDS patients with abnormal chest wall elastance¹. The goal of this study was to evaluate and compare virtual ARDS patient's respiratory mechanics with the results of this study.

METHODS. Virtual cases had ARDS, defined by various chest wall and pulmonary compliance, total resistance, lung volumes, pressure-volume relation, pressure and volume recruitment coefficients. Patients had initially the ARDS network lung protective protocol.²The pressure required to distend each part of the respiratory system were calculated as follow:

$P_{L\text{ inspi rel}} = P_{\text{platRS}} \times (1 - E_{\text{cw}}/E_{\text{rs}})$ where P_{platRS} was end inspiratory plateau pressure of the respiratory

system, $P_{L\text{ inspi rel}}$ was the elastance derived calculation of relative end inspiratory transpulmonary pressure.

If $P_{L\text{ inspi rel}}$ was below 25 cmH₂O, PEEP was increased in order to reach that level of pressure.

Respiratory mechanic after titration was recorded and compared to results of the study by Grasso et al.¹

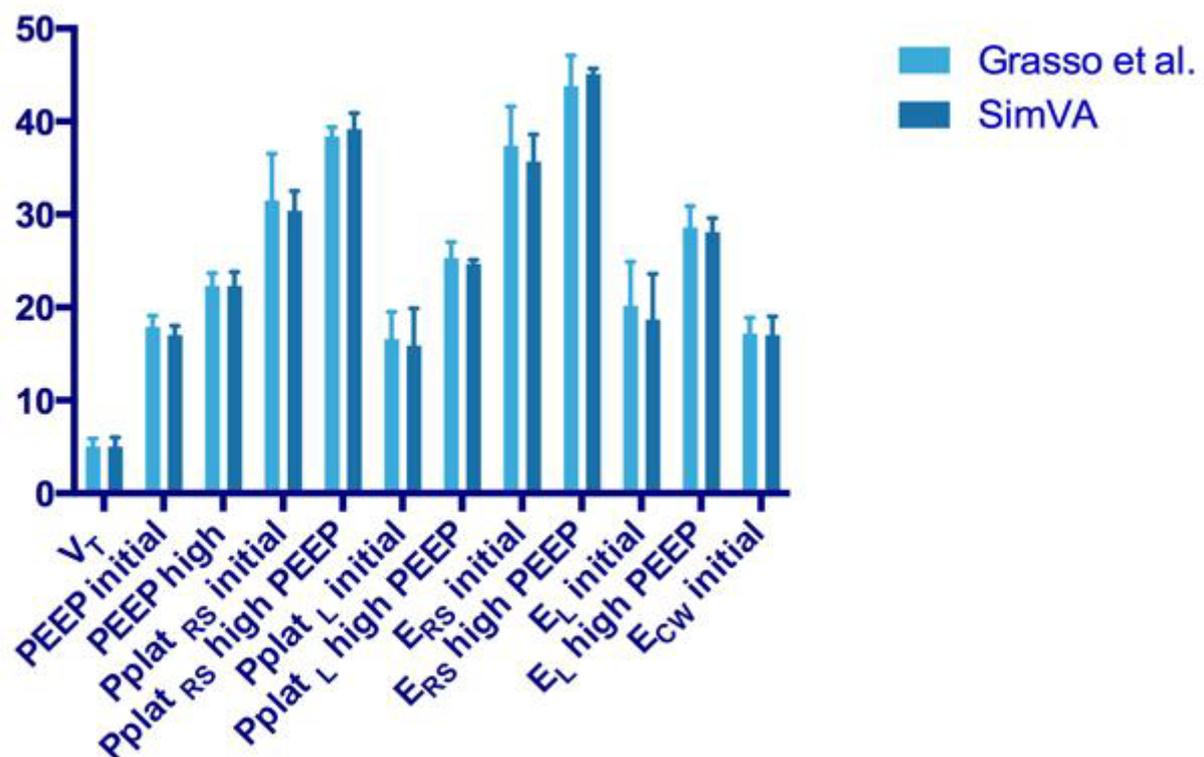
RESULTS. 7 real patients and 6 virtual cases were compared

The protocols defined PEEP level, the software calculates the corresponding values of inspiratory pressures and elastances. The difference between virtual cases and patients were not significant (Figure).

DISCUSSION. Elastances and $P_{L\text{ inspi rel}}$ were able to change according to PEEP settings within the same range as the study from Grasso et al.¹ These settings in real patients were able to increase significantly PaO₂/FiO₂ ratio and avoid VV-ECMO. Simulation with the software SimVA is realistic and may help to teach interactively $P_{L\text{ inspi rel}}$ monitoring in different cases of ARDS patients anywhere anytime without any risk for the patient.

	PEEP initial real	PEEP initial virtual	PEEP high real	PEEP high virtual
VT (ml)	5(0,9)	5(1)	5 (0,9)	5(1)
Pplat rs (cmH20)	31,5(5)	30,4 (2,1)	38,4 (1,0)	39,2(1,7)
PEEP (cmH20)	17,1(1,6)	17,9 (0,7)	22,3 (3,6)	22,3 (1,5)
PL inspi rel (cmH20)	16,6 (2,9)	15,9 (4)	25,3 (1,7)	24,7 (0,4)
Ers cmH20/L	37,4 (4,2)	35,7 (2,9)	43,8 (3,3)	45,1 (0,6)
EL cmH20/L	20,2 (4,7)	18,7 (4,9)	28,6 (2,3)	28,1 (1,5)
Ecw cmH20/L	17,2 (1,7)	17 (2)	15,2 (2,6)	0,47 (0,08)
ECW / Ers	0,47 (0,08)	0,48 (0,09)	0,47 (0,08)	0,37 (0,04)
RR cycle/min	31(6,0)	31,0(1,0)	31(6,0)	31,0(1,0)

[Respiratory Mechanic]



[Respiratory Mechanic]

009 Detailed measurement of esophageal pressures during mechanical ventilation using an advanced high-resolution manometry catheter

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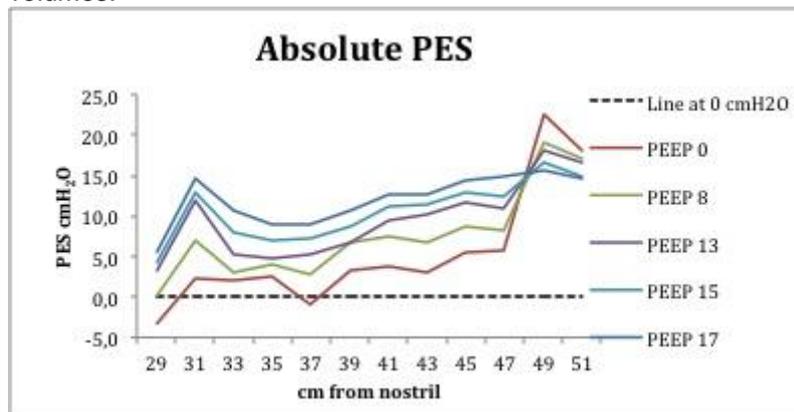
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INTRODUCTION. Esophageal pressure measurements are an important tool in determination of lung and chest wall mechanics and transpulmonary pressures during mechanical ventilation. Esophageal pressure measurements, traditionally obtained with a balloon catheter, have been shown to be influenced by several factors such as filling volume and positioning of the balloon [1, 2].

OBJECTIVES. To obtain more detailed knowledge about absolute pressures and pressure changes in the esophagus during mechanical ventilation.

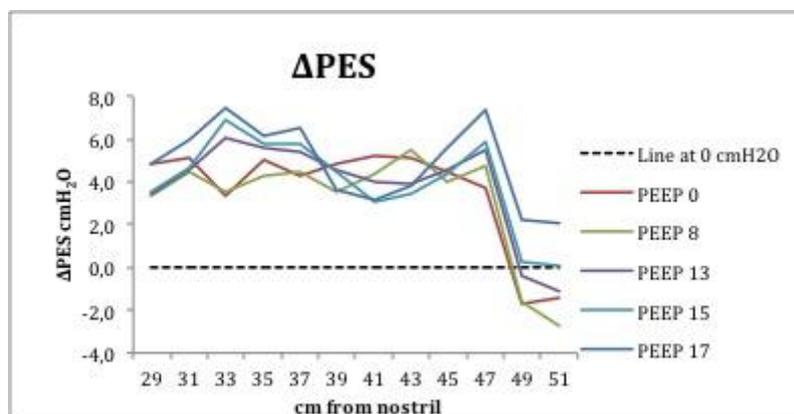
METHODS. In 20 patients in the intensive care unit and during general anesthesia, esophageal pressures were measured using a high-resolution solid-state manometry catheter [3, 4] with 36 circumferential sensors spaced at 1 cm intervals. During measurements different PEEP-levels and tidal volumes were applied and absolute pressures and tidal pressure changes recorded. In 12 patients esophageal pressures was also measured with a balloon catheter (SIDAM, Mirandola, Italy) for comparison.

RESULTS. Along the esophagus there is a wide range of absolute pressures with different patterns in different patients. Changes of PEEP have different effects on the absolute pressures in different part of the esophagus (Fig 1). The sizes of tidal pressure variations varied in different parts of the esophagus (Fig 2) and were affected in an inhomogeneous way by changes of PEEP and tidal volumes.



[Fig 1]

Fig 1 Absolute end-expiratory esophageal pressures in a patient in the ICU during controlled mechanical ventilation at different PEEP-levels.



[Fig 2]

Fig 2 Esophageal pressure changes in a patient in the ICU during tidal ventilation with 480 ml at different levels of PEEP

CONCLUSIONS. Absolute esophageal pressures and tidal pressure changes during mechanical ventilation are not uniform along the esophagus. A detailed knowledge about the variation in esophageal pressures is desirable when interpreting pressures obtained from balloon catheters and applying them in calculations of lung and chest wall mechanics.

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010 Biomonitorization of invasive mechanical ventilated patients with severe exacerbation of chronic obstructive pulmonary disease, with neutrophilic inflammation markers in bronchoalveolar lavage

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INTRODUCTION. Chronic obstructive pulmonary disease (COPD) is characterised by a non-specific inflammation. During exacerbations of COPD, neutrophils are increased. Molecules associated with neutrophilic inflammation could potentially serve as biomarkers of severity and prognosis of COPD exacerbations in intensive care units (ICU).

OBJECTIVES. Evaluation of neutrophilic inflammatory markers obtained from bronchoalveolar lavage (BAL) during first three days in ICU, due to exacerbation of COPD that needs invasive mechanical ventilation (IMV); and their relation with prognostic factors.

METHODS. We made a prospective observational cohort study. We analyse patients who need hospitalization in ICU because of COPD exacerbation, and who undergo IMV.

We take samples of BAL in days 1 and 3 of stay. We study concentration of neutrophilic inflammatory markers: GMCSF, IFN, IL10, IL12, IL17a, IL1B, IL4, IL23, IL6, IL8 y TNFa. We use multiplex array test for the analysis. We collect personal information, analytics, treatment and evolution. Statistical analysis were made using Chi-squared test, Mann-Whitney U-test, and correlation of Pearson test (SPSS 18 statistical package). Significance was established as $p < 0.05$.

RESULTS. 40 samples were evaluated. Median age of patients was 69.6 years (60-74); 83.3% were males. Median ICU stay was 6 days (4-9), and global mortality was 20%. Score of severity: APACHE II was 25,5 (20,5-31,5). We did not find differences between first and third BAL concentration of neutrophilic inflammatory markers. There was a positive correlation among ICU stay and levels on first day of GMCSF ($r: 0,928$; $p < 0.001$) and IL6 ($r: 0,745$; $p = 0.002$). This correlation persists for hospital stay and first day BAL GMCSF ($r: 0.706$; $p = 0.007$) and BAL IL6 ($r: 0.557$; $p = 0.048$). We did not find correlation among any of the inflammatory molecules studied and other prognostic factors as APACHE, SOFA, or global mortality.

CONCLUSIONS. Local inflammation measured with IL6 and GMCSF on the first day BAL from patients with severe COPD exacerbation and invasive mechanical ventilation, can be used to predict ICU and hospital length of stay; but do not correlate with severity scores neither with mortality. Determination of inflammatory markers in BAL could be a challenge to manage patients with severe exacerbation of COPD in ICU.

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011 PEEP selection in patients with acute respiratory distress syndrome (ARDS): when there is more than one best respiratory system compliance-information via electrical impedance tomography

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INTRODUCTION. PEEP selection based on best respiratory system compliance (Crs) during decremental PEEP titration is one of the most frequently used method in ARDS patients. There existed however more than one best Crs in some patients.

OBJECTIVES. What's the relative collapse and hyperdistension proportion when the Crs is similar between two PEEP levels.

METHODS. Patients with ARDS received decremental PEEP titration at 5 levels of PEEP (25, 20, 15, 11, 7 cmH₂O) following a short cycle of recruitment maneuver. All cases were under constant flow and volume cycle ventilation with tidal volume(Vt) between 6-8ml/Kg at PEEP of 15, 11, 7 cmH₂O. 75%Vt in PEEP₂₀ and 50%Vt in PEEP₂₅. We defined the measured Crs between different PEEP is of insignificant difference when the difference is less than 1 ml/ cmH₂O. Estimation of lung collapsibility and hyperdistension was obtained via regional lung compliance changes from electrical impedance tomography(EIT) recording at five PEEP levels according to the method of Costa et al¹.

RESULTS. Eight of the 23 ARDS cases examined had two PEEP levels with minimal difference in Crs. In these eight cases, higher PEEP(PEEP_H) averaged 11.7 ± 1.6 cmH₂O and lower PEEP(PEEP_L) averaged 7.5 ± 1.5 cmH₂O. The Crs in the PEEP_H group is 39.4 ± 11.2 vs 39.4 ± 11.1 cmH₂O in PEEP_L group ($p > 0.05$). All could be regarded as best Crs. The degree of lung collapsibility between PEEP_H and PEEP_L was significantly different ($5.9 \pm 3.7\%$ in PEEP_H vs $18.6 \pm 4.4\%$ in PEEP_L, $p < 0.05$) and there is also significant difference in degree of lung hyperdistension ($7.0 \pm 5.1\%$ in PEEP_H vs $0.3 \pm 0.5\%$ in PEEP_L, $p < 0.05$). The degree of lung collapse above 15% was found in 75% cases when PEEP_L was selected.

CONCLUSIONS. As there is a high probability of excessive lung collapse when PEEP_L was chosen, we recommend PEEP_H should be chosen or PEEP_L +2-3 cmH₂O be selected for PEEP setting in ARDS patients.

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012 Effects of inspiratory airflow on determinants of VILI: preliminary results in mild and moderate ARDS patients

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INTRODUCTION. Mechanical ventilation (MV), a lifesaving treatment for acute respiratory distress syndrome (ARDS) patients, can itself increase lung injury (VILI). The effects of inspiratory airflow, a often neglected MV setting, on the determinants of VILI are mostly unknown (1).

OBJECTIVES. We analysed the effects of inspiratory airflow on transpulmonary pressure measured

by esophageal pressure (Pes) and ventilation heterogeneity measured by electrical impedance tomography (EIT) (2,3). Study hypothesis was that lower flow rates could result in lower values. **METHODS.** We conducted a prospective interventional randomized cross-over study on 6 sedated and paralyzed patients with mild and moderate ARDS (Berlin definition) undergoing volume-controlled ventilation (VCV, S1 ventilator, Hamilton Medical, Bonaduz, Switzerland). Informed consent was obtained following local regulations.

We randomly set two PEEP levels (5 and 15 cmH₂O), while keeping Vt of 6-8 ml/kg PBW and clinical FiO₂, and we set the ventilator I:E ratio (no end-inspiratory pause) to obtain inspiratory airflow of 400±100 ml/sec, 800±100 ml/sec and 1200±100 ml/sec at each PEEP level (10 minutes per airflow). Pes, airway pressure (Paw), airflow and EIT data were continuously monitored. We measured at each step: Vt; end-inspiratory Paw after 2-3 seconds of occlusion (Pplat); total positive end-expiratory pressure (PEEPtot); respiratory system compliance (Crs = Vt/Pplat-PEEPtot); Paw at zero flow during and end-inspiratory occlusion (P1); transpulmonary pressure (PI = Paw - Pes) at P1 and at Pplat. EIT data were analyzed to measure distribution of ventilation in non-dependent and dependent lung regions and its heterogeneity (i.e., the number of ventilated pixels in the non-dependent lung region divided by ventilated pixels of the dependent lung).

RESULTS. Patient were 62 [54-64] yo, undergoing mechanical ventilation since 2 [2-3] days. On the day of the study, PaO₂/FiO₂ was 212 [188-244] and 3 patients (50%) had moderate ARDS. Table 1 summarizes relevant results: as expected, Pplat and Crs were not affected by modification of inspiratory airflow. P1 increased significantly at increasing airflow. PI at Pplat didn't change with increasing airflow. Increase of PI values, instead, were registered at P1 for higher airflow. The difference between P1 and Pplat (i.e., another sign of lung heterogeneity) increased with airflow, as well as EIT-based measure of ventilation heterogeneity.

Variable	PEEP 5 - Low airflow	PEEP 5 - Intermediate airflow	PEEP 5 - Elevated airflow	PEEP 15 - Low airflow	PEEP 15 - Intermediate airflow	PEEP 15 - Elevated airflow	P-value PEEP	P-value airflow	P-value interaction
Pplat (cmH ₂ O)	15.5 [13.0-18.0]	15.5 [13.0-16.0]	15.0 [13.0-16.0]	25.5 [24.0-26.0]	25.5 [23.0-26.0]	25.5 [23.0-27.0]	<0.001	0.839	0.565
Crs (ml/cmH ₂ O)	53.2±20.7	49.7±13.6	50.8±15.8	50.2±20.4	45.9±13.5	49.5±18.0	0.428	0.247	0.556
P1 (cmH ₂ O)	16.8±3.0	16.8±2.8	17.3±2.9	26.8±1.8	27.7±2.3	28.7±3.4	<0.001	0.045	0.293
PI at Pplat (cmH ₂ O)	0.0±1.2	0.3±1.5	-0.4±0.8	7.7±3.2	8.0±2.2	8.1±2.1	<0.001	0.724	0.431
PI at P1 (cmH ₂ O)	1.6±1.9	1.2±1.3	1.7±0.8	8.8±2.9	9.5±2.9	11.1±2.6	<0.001	0.053	0.106
P1 - Pplat (cmH ₂ O)	1.7±0.5	1.8±0.8	2.3±1.0	1.8±0.8	2.8±1.5	3.7±1.6	0.104	0.014	0.123
Ventilated lung units, non-dependent (%)	71 [62-77]	68 [63-78]	68 [63-77]	55 [48-60]	57 [48-62]	57 [48-60]	0.008	0.815	0.278
Ventilated lung units, dependent (%)	30 [23-38]	32 [22-37]	32 [23-37]	46 [40-52]	44 [38-52]	44 [40-52]	0.006	0.720	0.172
Ventilation heterogeneity, change from baseline (%)	baseline	+3 [-1 - +5]	+1 [-2 - +5]	baseline	+2 [+1 - +10]	+2 [+1 - +10]	-	0.031	-

[Table 1. Study results]

CONCLUSION. Although preliminary, the present results might suggest that increasing inspiratory airflow could yield higher transpulmonary pressure and heterogeneity, two possible determinants of VILI.

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013 Positive end-expiratory pressure ventilation induces longitudinal atrophy in diaphragm fibers

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INTRODUCTION. Critically ill patients often develop diaphragm weakness which leads to prolonged ventilator dependency, hospital stay, and increases mortality and health care costs. Mechanisms underlying diaphragm weakness include cross-sectional atrophy and contractile dysfunction of individual diaphragm muscle fibers, but whether shortening of diaphragm fibers (*i.e. longitudinal atrophy*) occurs is unknown.

OBJECTIVES. To study the hypothesis that an increased end-expiratory lung volume during positive end-expiratory pressure (PEEP) mechanical ventilation causes (1) caudal displacement of the diaphragm and shortening of diaphragm fibers, (2) adaptation of the shortened diaphragm fibers, and (3) that the giant mechanosensing protein titin is involved in this adaptation.

METHODS. Diaphragm displacement and muscle fiber shortening during 2, 3, 5 cmH₂O of PEEP ventilation were examined in shortly mechanically ventilated wild type rats. Diaphragm fiber adaptation and the role of mechanosensor titin during long-term fiber shortening upon 2.5 cmH₂O PEEP ventilation were studied in 18 hours mechanically ventilated wild type rats, and rats with a more compliant titin isoform (RBM20 knockout rats).

RESULTS. This study shows that (1) PEEP ventilation leads to caudal diaphragm displacement (0.24mm/cmH₂O PEEP), shorter diaphragm fibers at 2.5 cmH₂O PEEP (18.0±0.5 vs. 19.9±0.4mm; p=0.01), and shorter sarcomeres - the smallest contractile units in the muscle - (2.64±0.06 vs. 2.85±0.07µm; p=0.04) at the end of expiration. (2) After 18h of 2.5 cmH₂O PEEP ventilation, diaphragm fibers adapt to the shorter sarcomere length by reducing the number of sarcomeres in series with 12% (5488±128 vs. 6250±170 sarcomeres; p=0.004). (3) Rats with a more compliant titin isoform did not show a reduced number of sarcomeres in series after 18h of PEEP ventilation (PEEP vs. control: 7005±777 vs. 7155±424 sarcomeres; p=0.70).

CONCLUSION. Long-term mechanical ventilation with PEEP results in longitudinal atrophy of diaphragm fibers in wild type rats. This response is modulated by the compliance of the giant mechanosensing protein titin. We postulate that longitudinal atrophy, together with cross-sectional atrophy, contributes to a lower force generating capacity of the diaphragm during spontaneous breathing trials in critically ill patients. During these trials PEEP, and thus the end-expiratory lung volume are reduced, which stretches the shortened diaphragm fibers to excessive sarcomere lengths. At these long lengths, muscle fibers generate less force and diaphragm weakness ensues.

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014 Calculation of pulmonary elastance by variations of pulmonary artery occlusion pressure during controlled mechanical ventilation

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INTRODUCTION. During controlled ventilation there are few studies relate the mechanics of the respiratory system and occlusion pressure pulmonary artery (WCP) (1,2). Considering that WCP is measured by catheter with intrapulmonary insertion, we hypothesized that in a patient mechanically ventilated there should be some relationship between the changes in WCP and lung elastance (EL).

OBJECTIVES. To evaluate the usefulness of WCP variations during the mechanical respiratory cycle for the calculation of EL.

METHODS. We studied 33 consecutive patients during controlled mechanical ventilation, who had a pulmonary artery catheter for routine clinical management. Signals of flow (\dot{V}), airway pressure (Paw), esophageal pressure (Pes) and WCP, at sampling 560Hz were recorded. Volume (V) was calculated by integration of \dot{V} . Measurement of the mechanics of the respiratory system (Rs) and his compartment, was performed by multiple linear regression between \dot{V} , V, Paw or Ptp (transpulmonary) respectively. Regression between WCP, \dot{V} and V provided the mechanical data obtained by pulmonary artery catheter, which was compared with that obtained by Ptp. Statistical analysis: The data are expressed as means \pm SD, frequencies or percentage. The comparison was made by student t or non-parametric tests, as appropriate. Regression and Bland-Altman analysis was used to assess the agreement of adjustment.

RESULTS. Male 29 (87.9%). Age 54.24 ± 12.59 years. Diagnoses: Postoperative Pulmonary Transplant 26, (single: 14, double: 12); Acute Respiratory Distress: 7.

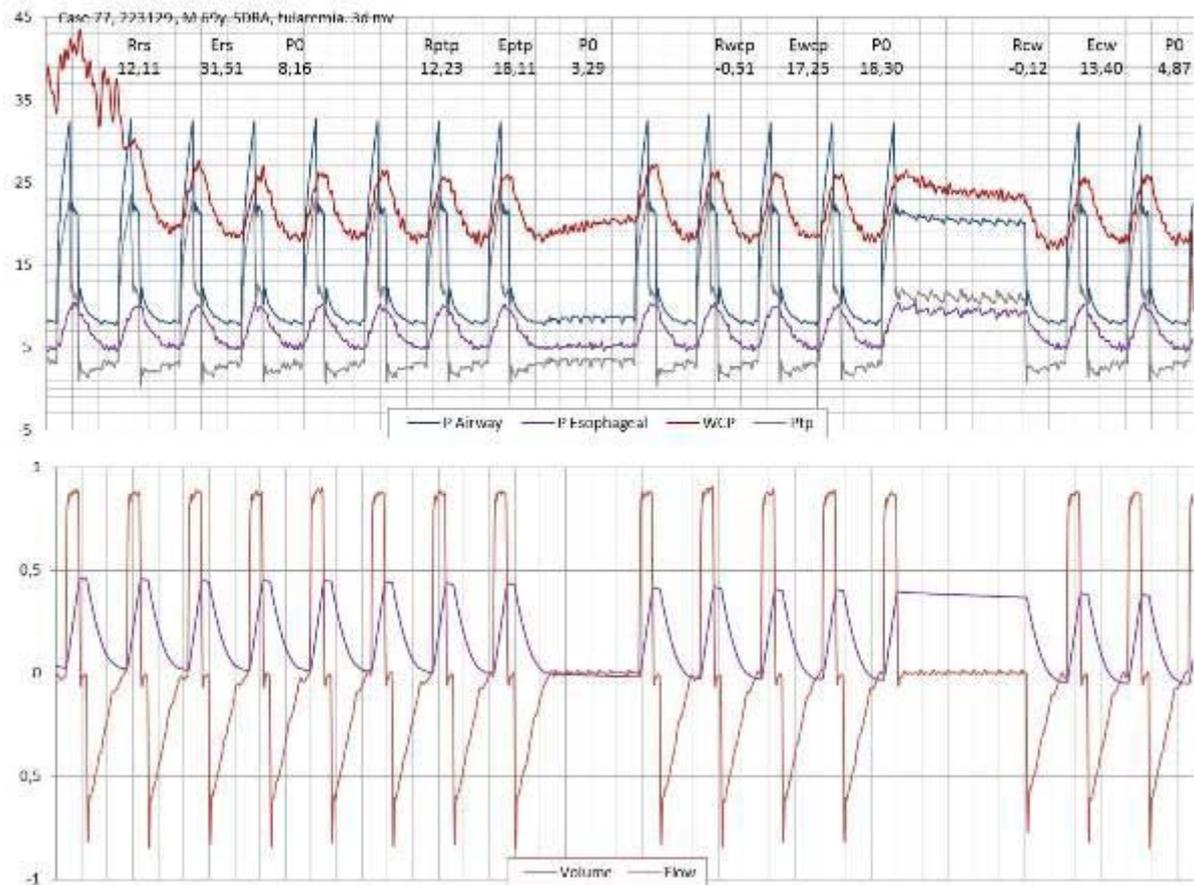
Global Respiratory Components: Rrs 14.08 ± 5.30 cmH₂O / L / s, Ers 30.08 ± 7.08 cmH₂O / L, Eptp 21.53 ± 6.15 cmH₂O / L, Ecp 8.67 ± 3.0 cmH₂O / L, Ewcp 19.42 ± 5.94 cmH₂O / L, Peep 6.06 ± 1.92 cmH₂O, \dot{V} 0.71 ± 0.14 L / s, Vt 0.48 ± 0.08 L, RR 20.26 ± 2.42 / min.

Table1: Concordance of the measurement methods. E = Elastance. Ers = Elastance of total respiratory system. E ptp= Total Elastance (ERs) - Elastance of thoracic wall (Ecp).

Elastance (cmH ₂ O/L)	Mean (SD)	P	Bias (SD)	Limits agreement, CI 95%	Regression equation (cmH ₂ O/L)	R
Etp vs Ewcp	21.49 (6.06) 19.51 (5.87)	0.183	-1.98 (3.17)	-8.32 a 4.36	Ewcp = 1.603+ (0.833*Etp)	0.86
Ers vs Ewcp+Ecp	30.03 (6.98) 28.34 (7.37)	0.341	-1.96 (3.56)	-0.09 a 5.13	Ewcp+Ecp = 0,629 + (0.913*Ers)	0.88
Ers vs Ecp	30.08 (7.08) 8.68 (3.00)	<0.001	-21.40 (6.14)	-33.68 a -9.12	Ecp = 2.239 + (0.214*Ers)	0.51

[Table: Concordance of the measurement methods.]

Figure1: Traces of Pressures, flow and Volume , during controlled ventilation in representative case. Note parallel changes between variations of pulmonary artery occlusion pressure (WCP) and volume, as well a similar elastance-related data obtained with transpulmonary pressure (Ptp).



[Figure 1: Traces of Pressures, flow and Volume, during controlled ventilation in representative case]

CONCLUSIONS. The variations of WCP during the respiratory cycle in controlled mechanical ventilation reflect changes in the elastic pressure of the lung.

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015 Pressure ulcers following prone positioning in ARDS patients

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INTRODUCTION. Prone positioning (PP) is a therapeutic intervention to improve oxygenation in patients with severe ARDS (acute respiratory distress syndrome). [1] Several clinical studies evaluated the safety and efficacy of PP in mechanically ventilated patients, however a higher frequency of pressure ulcers has been reported. [2] This study explores the incidence of pressure ulcers in PP patients with severe ARDS.

METHODS. Observational retrospective analysis of 1770 patients admitted to our ICU of tertiary level hospital from January 2013 to December 2017 was performed. Only the patients undergoing PP for at least 12 hours were included. The Braden scale was used to assess the patients' risk of developing a pressure ulcer at ICU admission while the pressure ulcers were staged according to the NPUAP staging system (National Pressure Ulcer Advisory Panel). Age, sex, BMI, length of stay in ICU, ECLS support, mortality were recorded along with the report of pressure ulcers developed on the front of the body.

RESULTS. A total of 119 patients treated with PP were identified in the medical records. In this sample, the pressure ulcers incidence was 39% and the main part of the body with pressure ulcers were: chin (21.5%), nose (18.4%), cheekbone (16.9%), rib cage (15.4%), hip bones (12.3%), knees (9.2%), others (6.1%). No adverse events occurred during the pronation procedures. In this study we found that patients with at least one pressure ulcer have a higher mortality rate and most of them need (57.4%) ECLS support (veno-venous ECMO). The score of Braden scale identified the high risk for both groups with a lower specificity. The most part of pressure ulcers (56.8%) were on the face area: this suggest that preventive measures to protect the skin should be implemented during PP. The other results are summarized in the table 1.

CONCLUSIONS. In this sample, PP is a safe procedure but it is associated with a risk of pressure ulcers in the front of the body especially in the face area.

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Characteristic	Pressure Ulcers (n=47)	No Pressure Ulcers (n=72)	p.value
Sex (male)	36 (76.5%)	40 (55.6%)	0.02
Age (mean, SD)	55±16	52±16	0.29
ICU discharge (days)	29±21	22±17	0.07
Mortality (%)	23 (48.9%)	21 (29.2%)	0.03
ECLS Support (%)	27 (57.4%)	26 (36.1%)	0.03
Braden score (mean, SD)	10±3	10±3	0.28
Body Mass Index (mean, SD)	26±2	25±5	0,98

[Main results of the study]

016 Ventilatory and gasometric changes during the use of heated humidifiers in patients under invasive mechanical ventilation

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INTRODUCTION. Gas delivered during mechanical ventilation (MV) must be warmed and humidified to avoid complications related to dry gases. The humidification and heating tasks can be performed either actively, by heated humidifiers (HHs), or passively, by heat and moisture exchangers (HMEs). Until now, there is no superiority of HMEs or HHs, in terms of clinical outcomes.

OBJECTIVES. To evaluate the possible changes in gasometric and ventilatory variables caused by the use of a HHs in patients receiving invasive mechanical ventilation.

METHODS. Longitudinal, quasi-experimental, nonrandomized, pre-post intervention study. We included all the patients under invasive mechanical ventilation who received gas humidification by HHs during the study period. There were no exclusion criteria. Demographic, clinical, gasometric and ventilatory variables were recorded. The measurements were performed 30-180 minutes after the change of the humidification system, without manipulating either the respiratory support or the pharmacological treatment. The intervention was performed according to clinical criteria without disturbing the regular clinical practice. Continuous variables were expressed as mean ± standard deviation, and categorical variables were expressed as the absolute number and proportions (%). Comparisons between variables were performed with Student's t test.

RESULTS. Twenty-eight patients were included, with a mean age of 58,2 years (64% male). The principal cause of admission was the respiratory failure (39%), mainly acute hypoxemic failure (71% progressed to acute respiratory distress syndrome). When a HHs was used, there was a decrease of

11, 4 mmHg (CI: 95%: 9 - 14, $p=0,00(1)$) in mean patient PaCO₂ when compared with the HMEs device, as well as an increase of 0,07 in mean pH (CI 95%: 0.089 - 0.60, $p=0,00(1)$). No adverse events were observed.

CONCLUSIONS. The use of a HHs compared to a HMEs was associated with significant gasometric changes due to a dead space reduction. This could be clinically relevant in a selected critical care population.

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017 A tool for automatic heart rate detection and removal of cardiogenic artifacts in esophageal pressure recordings

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INTRODUCTION. Esophageal pressure (Pes) signals are often subject to strong cardiogenic artifacts, which substantially complicates the assessment of lung mechanics and respiratory activity. Previous filtering approaches are known to either reduce the signal fidelity (like lowpass filtering) or to rely on external reference signals (like template subtraction or adaptive filtering).

OBJECTIVES. The aim of this proposal is to validate a novel tool, that automatically detects and removes cardiogenic artifacts in esophageal pressure datasets. The software is intended for retrospective processing of study data and should provide an intuitive way for clinicians to automatically improve Pes measurements.

METHODS. The software identifies the instantaneous heart rate directly from the esophageal pressure signal using a short-time autocorrelation method. Thereby the need for an external cardiac reference signal is circumvented. From the heart rate, an estimate of the cardiac phase is derived, which enables the application of all standard approaches known for the removal of periodic artifacts. In this evaluation, artifact removal is realized by the subtraction of pressure templates, which are formed according to the cardiac phase estimate. The proposed software was validated on clinical recordings of nine patients with different degrees of cardiac interference, all ventilated by Pressure Support Ventilation. As a reference, the standard template subtraction method [1], using R-waves in the ECG for artifact detection, was employed.

RESULTS. The absolute average error (AAE) of the Pes-based heart rate estimate over all nine patients was 0.91 ± 0.77 BPM (mean \pm standard deviation). The strength of the cardiogenic interference was quantified by means of the periodicity measure (PM), described in [2], which measures the amount of periodicity synchronous to the cardiac pace, where $PM=0$ indicates an aperiodic signal and $PM=1$ indicates a fully periodic one. The PM in the frequencies above 2 Hz of the unfiltered Pes signal was 0.69 ± 0.14 . The proposed method reduced the PM to 0.10 ± 0.06 , the standard ECG-based template subtraction reduced the PM to 0.09 ± 0.04 (both measured in the frequencies above 2 Hz).

CONCLUSIONS. The proposed software reliably removes cardiogenic interference in esophageal pressure signals and does not rely on external reference signals to detect artifacts. It may significantly facilitate the evaluation of large clinical datasets.

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018 Effects of positive end-expiratory pressure on diaphragm position and structure

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INTRODUCTION. Diaphragm weakness is highly prevalent in critically ill patients and is associated with weaning failure, increased length of hospital stay, and mortality. It is well known that inappropriate levels of inspiratory assist may result in diaphragm weakness. In particular, disuse of the respiratory muscles is associated with muscle fiber atrophy and activation of proteolytic pathways. However, the effect of positive end-expiratory pressure (PEEP) applied with mechanical ventilation on diaphragm structure and function has not been investigated. By increasing the end-expiratory lung volume, PEEP displaces the diaphragm in a caudal direction, thereby affecting its length-force relationship.

OBJECTIVES. To test the hypothesis that mechanical ventilation with PEEP could contribute to diaphragm weakness in critically ill patients.

METHODS. To study the acute effects of PEEP ventilation on diaphragm position and structure, ultrasound was performed in both mechanically ventilated critically ill patients and rats during a change in PEEP level. Furthermore, fixated diaphragms of mechanically ventilated rats were studied after a short period of 2.5 cmH₂O PEEP ventilation. To study the effect of long-term PEEP ventilation on diaphragm structure, rats were mechanically ventilated for 18 hours with PEEP of 2.5 cmH₂O, after which the whole diaphragm was excised and studied. The control group was ventilated for 15 minutes.

RESULTS. In ventilated patients, acute PEEP reduction caused a cranial displacement of the diaphragm. On average, an acute reduction of 5 cmH₂O (n=5) and 10 cmH₂O (n=10) caused a cranial displacement of respectively 0.40±0.10 cm and 0.89±0.17 cm respectively. In rats, application of PEEP caused a caudal movement of 0.24mm/cmH₂O. This caudal movement in rats caused a reduction in diaphragm fiber length of the mechanically ventilated rats in comparison to unassisted breathing rats (18.0±0.5 with PEEP vs. 19.9±0.4 mm in non-ventilated rats) and a reduced sarcomere length (2.64±0.06 vs. 2.85±0.07 μm). The number of sarcomeres in series was reduced by 12% in rats ventilated with PEEP compared to the control group (5288±128 vs. 6250±170 sarcomeres).

CONCLUSIONS. PEEP affects the position of the diaphragm in both critically ill patients and rats. In rats, PEEP results in a reduced muscle fiber length and sarcomere length. After 18 hours of mechanical ventilation with PEEP longitudinal atrophy develops due to absorption of sarcomeres. This longitudinal atrophy could have detrimental effects during a weaning trial without PEEP, as the muscle fibers are overstretched and may be prone to injury. Since stretched fibers generate less force, this phenomenon could contribute to diaphragm weakness during weaning. More research to proof this concept in healthy subjects is currently initiated.

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019 Biological monitorization of patients with mechanical ventilation due to exacerbation of chronic pulmonary disease

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INTRODUCTION. Chronic obstructive pulmonary disease (COPD) is characterised by a non-specific inflammation. During exacerbations of COPD, neutrophils are increased. Molecules associated with neutrophilic inflammation could be used as biomarkers of severity and prognosis of COPD

exacerbations in the Intensive Care Unit (ICU).

OBJECTIVES. Evaluation of neutrophilic inflammatory markers in serum from patients with severe exacerbation of COPD requiring mechanical ventilation, and the relation with prognostic factors, during their hospitalization.

METHODS. We made a prospective observational cohort study. We analysed patients with severe exacerbation of COPD that required mechanical ventilation, who were admitted to Intensive Care Unit. We took blood samples the first and third day of ICU stay and the day of hospital discharge. The neutrophilic inflammatory markers studied were: GM-CSF, IFN, IL10, IL12, IL17a, IL4, IL23, IL6, IL8, and TNF α . We used multiplex array test for the analysis. We collected personal information, analytics, treatment, and evolution. Statistical analyses were made using Chi-squared test, Mann-Whitney U-test, and correlation of Pearson test (SPSS 18 statistical package). Significance was established as $p < 0,05$.

RESULTS. 90 samples were evaluated from 30 patients. Median age of patients was 69.6 years (60-74) with 83.3% being males. Median ICU stay was 6 days (4-9), and median hospital stay: 14 days (12-21). The global mortality was 20%. Severity score APACHE II was 25.5 (20.5-31.5) and SOFA: 6 (4-9). We found correlation between ICU stay and first day levels of IL6 ($r=0.378$; $p=0.04$), IL8 ($r=0.848$; $p < 0.001$), and TNF α ($r=0.671$; $p < 0.001$). There was also a positive correlation between first day IL6 and APACHE II ($r=0.452$, $p=0.016$). The analysis of SOFA score (sequential organ failure assessment) inversely correlates with first day levels of GM-CSF ($r=-0.666$; $p=0.013$), IFN α ($r=-0.633$; $p=0.02$), IL17a ($r=-0.703$; $p=0.007$), and IL1B ($r=-0.649$, $p=0.016$). Hospital stay was related with discharge levels of IL6 ($r=0.758$; $p=0.007$) and with first day levels of IL8 ($r=0.613$; $p < 0.001$) and TNF α ($r=0.462$, $p=0.012$). Mortality only correlates with the level of the inhibitory IL10 at the last day (17.84 (CI: 4.47-34.07) in survivors vs 270.7(CI: 26.52-514.8) in exitus; $p=0.029$).

CONCLUSIONS. In patients admitted to ICU due to exacerbation of COPD, we observed a prevalence of some inflammatory markers that could serve as severity and evolution factors (IL6, IL8, and TNF α). Organ dysfunction correlates with levels of protective factors on third day of stay (GM-CSF, IFN α , IL17a, IL1B), while length of stay (both ICU and hospital stay) correlates with blood markers on first day. Mortality is related to antiinflammatory factor IL10.

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020 Is respiratory quotient a useful tool for monitoring hemodynamic status and differential diagnosis of lactic acidosis? Case series study

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INTRODUCTION. Patients undergoing cardiovascular surgery often need fluid resuscitation. Lactate is one of the reliable variables which reflects tissue hypoxia, and it has been used as a therapeutic marker. However, high lactate levels in this situation do not always suggest tissue hypoperfusion. Therefore it is often difficult to determine necessity of fluid resuscitation. An indirect calorimetry is used to clinically ill patients to determine nutrition requirement. Especially, a respiratory quotient, which is measured by indirect calorimetry, is considered to reflect an anaerobic metabolism state^{*1}. Although this fact has been well known, respiratory quotient is not used as a hemodynamic parameter. There is no report of association between respiratory quotient and hemodynamic state in human despite of a published animal experiment ^{*2}.

OBJECTIVES. The aim of this study was to evaluate the efficacy of respiratory quotient for cardiovascular patients.

METHODS. DESIGN. Case series study.

Patients: Five patients were selected who underwent an elective cardiovascular surgery using cardiopulmonary bypass and monitored by indirect calorimetry.

RESULTS. All patients were male, and received an aortic replacement, valve replacement, valve plasty, or coronary artery bypass grafting. The vital signs and hemodynamic parameters were mostly stable. The measurements of Respiratory quotient during mechanical ventilation were between 0.7 to 0.8. One patient, who underwent descending aortic replacement, had hyperlactatemia when he was admitted to the ICU. His vital signs and hemodynamic parameters were as follows; blood pressure of

89/52 mmHg, mean arterial pressure of 65 mmHg, heart rate of 82 beats/min, cardiac index of 2.6 l/min/m² and stroke volume variation of 15%. Lactate was 4.69mmol/l. Respiratory quotient was 1.13. We determined the necessity of fluid resuscitation for this patient and administered Linger solution. Following the fluid administration, we checked all parameters again. His vital signs and hemodynamic parameters were as follows: blood pressure of 97/53 mmHg, mean arterial pressure of 70 mmHg, heart rate of 99 beats/min, cardiac index of 3.0 l/min/m² and stroke volume variation of 16%. Lactate was 6.21mmol/l. Respiratory quotient was 0.71. Despite of the increase in lactate levels after the fluid resuscitation, respiratory quotient obviously decreased. Resolution of hyperlactatemia took several hours.

CONCLUSIONS. A respiratory quotient may reflect necessity of fluid resuscitation in critically ill patients.

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021 Biomonitorization of immunologic kinetics in chronic obstructive pulmonary disease

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INTRODUCTION. Chronic obstructive pulmonary disease (COPD) is a prevalent chronic disease with exacerbations that have a high morbimortality, and represent important health expenses. It is characterised by a non-specific inflammation. During exacerbations of COPD, innate immune response is increased. Promising biologic treatments are developing. The study of the kinetics of molecules associated with inespecific inflammation could be used in the future to know how and when to treat severe COPD.

OBJECTIVES. To evaluate if serum levels of neutrophilic inflammatory molecules, leukocytes, Protein C Reactive (PCR), and fibrinogen, follow a specific kinetic pattern in COPD exacerbated patients, during Intensive Care Unit (ICU) hospitalization and after discharge.

METHODS. We studied a consecutive cohort of patients hospitalized in ICU due to severe COPD exacerbation. We took blood samples on first and third day of hospitalization, at the moment of hospital discharge, and 6-12 months later at external consultation when they are stable. Markers studied were:leukocytes,PCR, fibrinogen, GMCSF, IFN, IL10,IL12,IL17a, IL1B,IL4,IL23, IL6, IL8, and TNFa. We used multiplex protein arrays test to analyse these molecules. We collected personal information, analytics, treatment, and evolution data. We used variance analysis with post hoc test. Significance was established as p< 0.05

RESULTS. 120 blood samples from 30 patients were analysed. Median age of patients was 69.6 years (60-74) with 83.3% being males. Median ICU stay was 6 days (4-9), and median hospital stay: 14 days (12-21). The global mortality was 20%. Kinetic study showed a significant tendency to progressively diminish pro-inflammatory factors: leukocytes (p=0.007), neutrophils (p=0.025), fibrinogen (p=0.042), IL10 (p=0.045), IL6 (p=0.048), IL8 (p< 0.001); and a significant tendency to increase antiinflammatory IL4 (p=0.035). We did not observe significant differences in the evolution of blood levels of lymphocytes, eosinophils, PCR, GMCSF, IFN, IL12, IL17a, IL1B, IL23, TNF alpha.

CONCLUSIONS. It is necessary to learn more about the different systemic inflammatory markers during evolution of COPD patients, in order to better understand how and when we can use new promising biologic treatments needed to diminish the high morbimortality of this prevalent disease.

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022 Implementation of a spontaneous breathing trial protocol

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INTRODUCTION. Mechanical ventilation (MV) is a vital support used in a high percentage of patients in intensive care units. 20% of patients submitted to mechanical ventilation will fail in their first attempt to disconnect, and more than 40% of the total duration of MV will be used in the weaning process. Prolonged MV is associated with a high number of complications, an increase in the length of stay in the ICU and increase in hospital stay. A premature weaning followed by the need for reintubation is associated with an increase in morbidity and mortality. Classical criteria to evaluate the start of weaning have little specificity and sensitivity. Daily spontaneous breathing trials (SBT) are promulgated as the best method for assessing readiness for discontinuation of mechanical ventilation.

OBJECTIVE. Evaluate if the implementation of a SBT trial protocol reduces the duration of mechanical ventilation.

METHODS. A SBT protocol including three steps was carried out: a safety screen to determine the patient's readiness to undergo an SBT, a 2-min tolerance screen of intensive monitoring to assess whether the SBT should continue, and a 30-120 min SBT. The patient passes or failed based on agreed upon criteria for each step.

During the months of June to September 2010, 101 polyvalent patients were admitted in the ICU. 27 of them died. 27 did not require respiratory support. 8 patients received tracheostomy for prolonged MV and in 1 patient early tracheostomy was performed because of the underlying disease. Of the remaining 37 patients, 7 were extubated in less than 24 hours, 15 were extubated by applying the T-piece test and 15 were extubated by according to the protocol describe above.

RESULTS. In the group of patients extubated with the T-piece test, the mean age was 54.4 ± 18.2 years, being 80% men, with a mean APACHE II score of 12.4 ± 5.6 . The mean duration of MV was 9.67 ± 8.9 days, with an average stay in the ICU of 13.4 ± 10 days. The weaning failure rate was 6.67%. The group of patients who went under the SBT trial protocol, had a mean age of 64.47 ± 12.1 years, with 60% being men. The mean APACHE II score was 17.2 ± 3.4 . The length of MV was 6.47 ± 2.6 days, with an average stay in the ICU of 13.2 ± 8.7 days. Two patients failed at weaning.

CONCLUSIONS. The implementation of a SBT trial protocol can reduce the days of mechanical ventilation and therefore the days of ICU-stay and the hospital stay by identifying earlier the patients who are able to begin the weaning from mechanical ventilation.

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024 Carbon dioxide production and ventilatory inefficiency along a T-piece spontaneous breathing trial are associated with difficult weaning

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INTRODUCTION. Ventilatory monitoring along a T-piece spontaneous breathing trial (SBT) is limited. Carbon dioxide (CO₂) monitoring with time capnography has been used to identify hypoventilation along the weaning process, but with high number of false positives [1]. Volumetric capnography (VC) can provide direct or derivate physiological variables that may be associated with difficult weaning, such as CO₂ production (VCO₂) and ventilatory inefficiency calculated from the slope between minute

ventilation and VCO_2 (VE/VCO_2). Furthermore a good correlation between VE/VCO_2 and physiological dead space has been recently reported in mechanically ventilated patients [2].

OBJECTIVES. To evaluate if VCO_2 and/or VE/VCO_2 along a T-piece SBT are associated with difficult weaning.

METHODS. We prospectively performed a one-hour SBT with a CO_2 /flow sensor between the endotracheal tube and the T-piece. Data was continuously recorded on a personal computer connected to a VC monitor (NICO2, Wallingford, CT, USA). Mean VCO_2 and VE/VCO_2 slopes were calculated. Difficult weaning included 3 categories: SBT failure (SBT-F) defined as inability to complete the trial or to extubate upon its completion, post extubation respiratory failure (PERF) defined as the need of non-invasive ventilation within 48 hours after extubation and extubation failure (EF) defined as the need for reintubation within 48 hours after extubation. Associations between VC variables and weaning outcomes were explored with t-test and ROC curves.

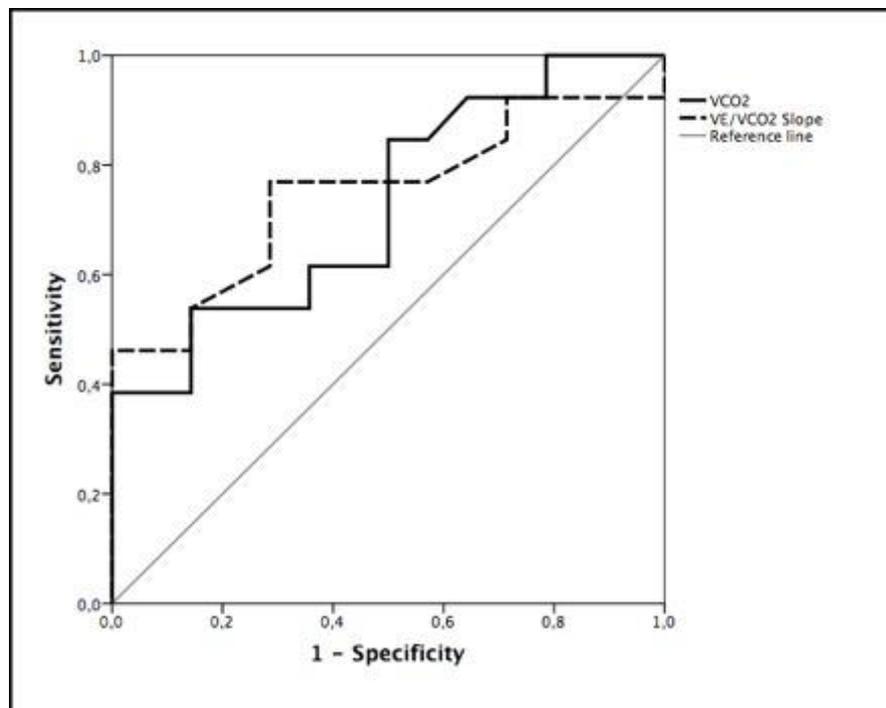
RESULTS. Twenty seven T-piece SBT were performed on 24 patients mechanically ventilated for 6 ± 5 days with an APACHE II of 17 ± 11 and a SOFA score 8 ± 3 points. 46% had sepsis/shock, 33% had acute respiratory failure and 21% were trauma/surgical. Sixteen trials presented difficult weaning; 5 with SBT-F, 7 with PERF and 4 with EF.

Patients with difficult weaning had a higher mean VCO_2 or VE/VCO_2 slope (table 1).

		VCO_2 (ml/min) (mean \pm SEM)		VE/VCO_2 slope (mean \pm SEM)	
Difficult Weaning	+	274 ± 22	$p= 0.020$	33 ± 3	$p= 0.021$
	-	212 ± 12		25 ± 2	

[Association between volumetric capnography variables and difficult weaning]

The AUC of the ROC curves of mean VCO_2 and VE/VCO_2 slope for difficult weaning were 0.73 [0.54-0.92] and 0.75 [0.55-0.94], respectively (figure 1).



[ROC curves: VCO_2 and VE/VCO_2 Slope respect to difficult weaning.]

Patients with SBT-F only had a higher mean VCO_2 (table 2), while patients with PERF only had a higher VE/VCO_2 slope (table 2).

Weaning outcomes		VCO ₂ (ml/min) (mean±SEM)		VE/VCO ₂ slope (mean±SEM)	
SBT failure	+	303 ± 35	p= 0.030	32 ± 7	NS
	-	228 ± 13		28 ± 7	
Post extubation respiratory failure	+	235 ± 21	NS	35 ± 4	p= 0.019
	-	212 ± 13		25 ± 2	
Extubation failure	+	254 ± 29	NS	34 ± 7	NS
	-	211 ± 12		27 ± 2	

[Association between volumetric capnography variables and weaning outcomes]

CONCLUSION. Mean carbon dioxide production and ventilatory inefficiency are associated to difficult weaning; specifically a higher VCO₂ is related to inability to tolerate a SBT and ventilatory inefficiency to the need for non-invasive ventilation after extubation.

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025 Lung recruitment assessment in ARDS - nitrogen dilution and simple mechanics versus computed tomography

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INTRODUCTION. Reversibility of lung collapse or lung recruitability (LR) is extremely variable in patients with acute respiratory distress syndrome (ARDS). Quantitative analysis of chest computed tomography (CT) is considered the gold standard for LR assessment. Respiratory mechanics have also been classically used for this purpose. Agreement between CT and respiratory mechanics for the quantification of LR has been reported as variable.

OBJECTIVES. To compare end-expiratory lung volume (EELV) measurements and LR quantification from CT and nitrogen dilution (ND) in ARDS patients.

METHODS. We measured static respiratory system compliance (Cst) and EELV by ND under two PEEP levels, 10 cmH₂O apart, with a lung recruitment maneuver in between. Recruited volume from ND was computed as the difference of PEEP-induced EELV change (ΔEELV) and Cst at the low PEEP level times 10. Thoracic CT scans were performed at end-expiration at both PEEP levels following the same sequence. Gas lung volume and aerated lung tissue mass were computed at both PEEP levels with a -100 HU threshold. LR from CT was defined as PEEP-induced increase in aerated lung tissue mass. Recruitment efficiency was defined as the ratio between recruited volume or mass and ΔEELV. Patients with auto-PEEP greater than 2 cmH₂O were excluded.

RESULTS. We studied 15 ARDS patients with a PaO₂/FiO₂ ratio of 122 ± 29 at PEEP 5 ± 4 and 15 ± 4 cmH₂O. Table 1 shows EELV at both PEEP levels, ΔEELV, LR and recruitment efficiency using CT and ND as well as their Pearson correlations, significance, bias and limits of agreement.

CONCLUSIONS. Lung volume measurements and recruitment quantification from CT and ND correlate well with small biases, but large limits of agreement. Bedside EELV measurements in conjunction with respiratory mechanics can be used as a reasonable LR estimate in ARDS patients although not interchangeably with CT.

REFERENCE(S). 1. Measurement of alveolar derecruitment in patients with acute lung injury: computerized tomography versus pressure-volume curve. Lu Q, et al. *Critical Care* 2006, 10:R952. 2. Lung Recruitment Assessed by Respiratory Mechanics and Computed Tomography in Patients with

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	Computed Tomography (mean±SEM)	Nitrogen Dilution (mean±SEM)	r	p	Bias	Limits of Agreement
EELV1 (ml)	782 ± 21	735 ± 19	0.915	<0.001	46	-336 to 429
EELV2 (ml)	1498 ± 25	1378 ± 21	0.884	<0.001	120	-502 to 742
ΔEELV (ml)	716 ± 19	642 ± 15	0.772	<0.01	74	-399 to 547
LR (g or ml)	384 ± 17	361 ± 15	0.885	<0.001	23	-252 to 298
LR/ΔEELV	0.53 ± 0.50	0.53 ± 0.42	0.815	<0.001	0.005	-0.28 to 0.29

[Table 1. EELV1: End expiratory lung volume at low PEEP, EELV2: EELV at high PEEP, LR: lung recruitability]