312. Recent technical developments in long-term noninvasive ventilation

2850

Pulse transit time allows a reliable non-invasive measurement of respiratory effort under non-invasive ventilation

Olivier Contal[1], Claudio Carnevale[2,3], Jean-Christian Borel[2,3,4], AbdelKebir Sabil[2,3], Renaud Tamisier[2,3], Patrick Levy[2,3], Jean-Paul Janssens[1], Jean-Louis Pepin[2,3]. *[1]Division of Pulmonary Diseases, Geneva University Hospitals, Geneva, Switzerland; [2]HP 2 Laboratory (Hypoxia: Pathophysiology), INSERM U 1042, Joseph Fourier University, La Tronche, France; [3]EFCR and Sleep Laboratory, Locomotion, Rehabilitation and Physiology Department, Grenoble University Hospital, Grenoble Cedex 09, France; [4]Research and Development Department, AGIR à Dom, Meylan, France*

Rationale: Among respiratory events which may occur during nocturnal non-invasive ventilation (NIV), differentiating between central and obstructive events requires appropriate indicators of respiratory effort.
Objective: To assess pulse transit time (PTT) as an indicator of respiratory effort under NIV in comparison with esophageal pressure (Pes).
Methods: 1: During wake period, PTT was compared to Pes during spontaneous breathing and under NIV with or without induced leaks in 11 healthy individuals.
2: To evaluate the contribution of PTT vs Pes for differentiating central from obstructive respiratory events occurring under NIV during sleep in 10 patients with obesity hypoventilation syndrome (OHS).
Results: 1: From spontaneous breathing to NIV without leaks, respiratory effort decreased significantly and with increasing level of leaks, there was a significant increase in respiratory effort. In both situations changes in PTT accurately reflected changes in Pes.
2: In OHS patients during nocturnal NIV, intraclass correlation coefficients between Pes and PTT were 0.970 for total number of events and 0.970 for percentage of central events.
Conclusion: PTT accurately reflects the unloading of respiratory muscles induced by NIV and the increase in respiratory effort during NIV. PTT during sleep is also useful to differentiate central from obstructive respiratory events occurring under NIV.
Clinical trial registration number: NCT00983411.

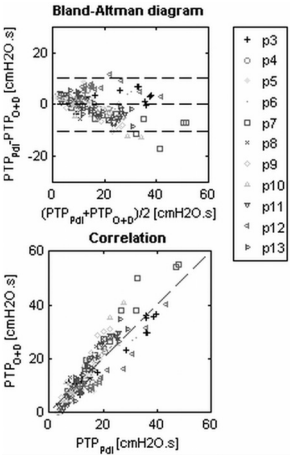
2851

Validation of a method for non-invasive assessment of transdiaphragmatic pressure during support ventilation

Kristel Lopez-Navas[1], Sebastian Brandt[2], Merle Strutz[1], Hartmut Gehring[2], Ullrich Wenkebach[1]. *[1]Laboratory of Medical Systems, University of Applied Sciences, Lübeck, Germany; [2]Department of Anaesthesiology, University Medical Centre Schleswig-Holstein, Campus Lübeck, Germany*

Especially during long term support ventilation continuous assessment of the patient's work of breathing can be helpful to improve the quality of the assistance. We designed the Occlusion+Delta (O+D) method to estimate non-invasively transdiaphragmatic pressure (Pdi) and started validation in a study with volunteers.
Methods: Respiratory flow and airway pressure were recorded from 11 healthy men (21 to 68 years old) during quiet spontaneous breathing, increased effort and supported by a ventilator in ASB mode. Pdi was measured for control using a double-balloon catheter. Each 3 to 5 cycles our method was applied getting an estimation of respiratory resistance R and compliance C used to reproduce the Pdi of the coming cycles, which was compared to the measured Pdi by their inspiratory pressure time products (PTP).

Results: The short occlusions required by O+D did not disturbed the volunteers and produced the expected signals. The obtained R (3.2 to 7.1cmH2O/l/s) and C (58.7 to 97.7ml/cmH2O) remained in the usual range for healthy adults. Regression and correlation analysis revealed high agreement between methods (PTP_{O+D} = 1.00*PTP_{Pdi}-0.02, r=0.92, R2=0.86). The overall differences (n=2420 (220 per volunteer)) were 0.01±10.3cmH2O.s (mean±2SD).



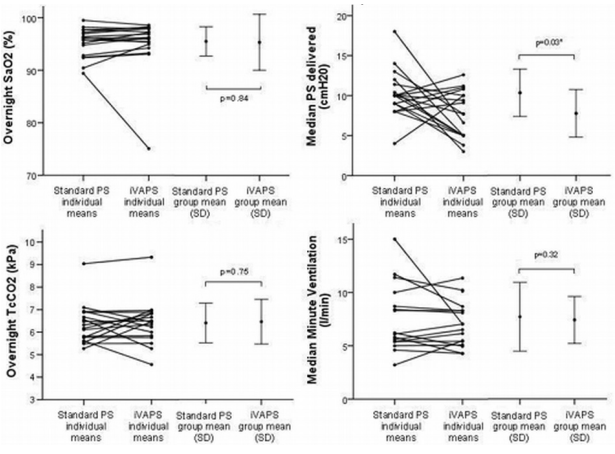
Conclusions: The results obtained demonstrate great potential in the developed method. A study with 30 volunteers is being carried out to complete validation.

2852

Initiation of nocturnal ventilation using an intelligent autotitrating non-invasive ventilator: Impact on ventilatory efficiency, sleep and adherence

Jay Jaye, Julia Kelly, Rachel Pickersgill, Michelle Chatwin, Mary Morrell, Anita Simonds. *Sleep and Ventilation Department, NIHR Respiratory Disease Biomedical Research Unit at the Royal Brompton and Harefield NHS Foundation Trust and Imperial College London, London, United Kingdom*

Intro: A novel intelligent non invasive ventilator allows automated set-up & delivery of volume assured ventilation within preset pressure support boundaries adjusting to patient requirements (iVAPS). iVAPS controls nocturnal hypoventilation (NH) comparably to standard non invasive pressure support ventilation (PS) in established NIV users. We hypothesise iVAPS is as effective as PS in naïve patients for controlling NH.
Methods: 18 patients with chronic obstructive or restrictive disorders & newly diagnosed NH, (mean(SD) age 51(17)yrs, mean day PaO_2 9.2(1.2)kPa, $PaCO_2$ 6.4(0.7)kPa) completed a randomised crossover study of iVAPS v PS (ResMed Ltd). Baseline FEV_1/FVC & respiratory muscle strength (RMS) were repeated at 1 month treatment, plus polysomnography.
Results: iVAPS used less PS for the same ventilatory outcome; 7.7(2.9) v 10.2(2.9)cmH20(p=0.03*).



No differences were seen for FEV_1/FVC, RMS or sleep quality; arousal index 16.9(9.2) v 18.1(12.0) (p=0.65), O_2 desaturation index 7.2(6.6) v 6.4(6.9) (p=0.59). Adherence was superior with iVAPS; 5.6(2.1) v 4.6(2.3)hrs/day(p=0.002). Patients expressed an iVAPS preference.
Conclusion: iVAPS is as effective as PS initiated by a skilled healthcare professional in controlling NH. It may facilitate NIV use without extensive prior team experience & may encourage compliance/adherence to therapy for patients newly adjusting to NIV.

2853

Impact of long-term target-volume noninvasive positive pressure ventilation on sleep quality

Jan Hendrik Storre[1], Elena Matrosovich[2], Emelie Ekkernkamp[2], Michael Dreher[2], Claudia Schmoor[3], Wolfram Windisch[1]. *[1]Pneumologie (Lungenklinik), Cologne-Merheim Hospital, Kliniken der Stadt Köln gGmbH, Witten/Herdecke University Hospital, Cologne, Germany; [2]Pneumology, University Hospital, Freiburg, Germany; [3]Clinical Trials Center, University Hospital, Freiburg, Germany*

Objective: Target-volume noninvasive positive pressure ventilation (TV-NPPV) was introduced to combine the advantages of volume- and pressure-preset NPPV. However, diverging results have been reported regarding a deterioration of sleep quality due to pressure variation.
Methods: 12 COPD-patients on long term high-intensity NPPV (HI-NPPV) were switched to TV-NPPV for 10 weeks. Sleep quality and overnight gas exchange were analyzed at run-in during HI-NPPV and after 10 weeks of TV-NPPV. Two TV-NPPV-settings were tested overnight in a randomized order: 8ml/kg ideal body weight (TV1) versus 110% of individual tidal volume analyzed during familiar HI-NPPV (TV2). Inspiratory pressures were set to -5mbar (of HI-NPPV) up to 35mbar. TV-NPPV-settings reflecting the lower overnight transcutaneous PCO2-values ($PtcCO_2$) were chosen for long-term TV-NPPV.
Results: 10 patients completed the study, 2 patients refused to complete the trial using TV2-NPPV at home. Mean overnight $PtcCO_2$ was similar during HI-NPPV and TV-NPPV (both 45±5mmHg), p=0.75. In addition, no difference was found comparing sleep quality by polysomnography regarding sleep efficiency, sleep stages, total sleep time, arousal index, apnoe-hypopnea index or oxygen saturation.
Conclusion: After 10 weeks of TV-NPPV at home no differences regarding sleep quality or overnight $PtcCO_2$ were observable compared to conventional HI-NPPV.

2854

Home polysomnography in the management of noninvasive ventilation in neuromuscular patients

Grazia Crescimanno, Francesca Greco, Oreste Marrone. *Institute of Biomedicine and Molecular Immunology, Italian National Research Council, Palermo, Sicily, Italy First Unit of Pneumology, V. Cervello Hospital, Palermo, Sicily, Italy Italian Union Against Muscular Dystrophy, Section of Palermo, Sicily, Italy*

Background: Patients with neuromuscular disease (NMD) on long-term noninvasive ventilation (NIV) require reevaluation of ventilator setting, which is better performed during nocturnal polysomnography (PSG). Studies on the role of home PSG in the management of NIV in NMD patients are lacking.
Objective: To compare feasibility, reliability, subjective and objective sleep quality and patients' acceptance of PSG during NIV performed either in hospital or at home.
Methods: Fifty-two consecutive NMD patients on long-term NIV were assigned to home or to unassisted hospital PSG during NIV application. A 7 item self-questionnaire was administered after PSG to explore perceived sleep efficiency, sleep quality, awakenings, and acceptance of the polysomnographic procedure. Sleep was scored according to AASM rules.
Results: One home and 1 hospital PSG were not reliable due, respectively, to insufficient sleep or to signal loss. Four hospital and three home recordings showed minor technical problems that did not affect their reliability. The remaining 43 recordings were technically excellent both as regards neurological and respiratory signals. Subjective (382.80±114.28 vs 347.94±77.3 minutes, respectively) and objective total sleep time and sleep efficiency (68.80±19.40 vs 72.03±15.86%), that were correlated to each other, were similar in the two groups. Acceptance of home PSG (8.28±1.99 on a scale from 0 to 10) was higher than for hospital PSG (6.84±2.42, p=0.02)
Conclusion: In ventilated NMD patients, feasibility and reliability of PSG, as well as subjective and objective sleep quality, do not differ if it is performed in hospital or at home. Acceptance of the procedure in the home environment is higher.

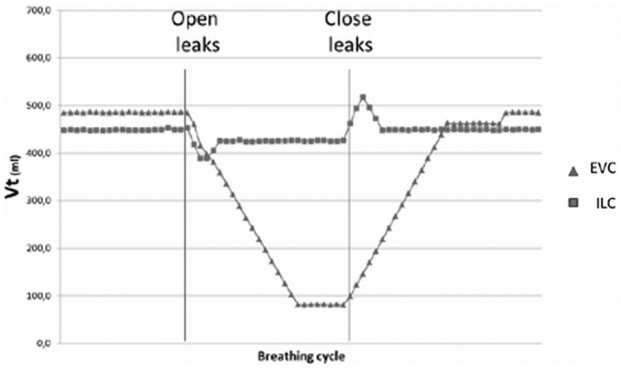
2855

Is volume assured ventilation always able to compensate volume loss in presence of leaks?

Annia Schreiber[1], Annalisa Carlucci[1], Piero Ceriana[1], Alessio Mattei[3], Cesare Gregoretti[2]. *[1]Respiratory Intensive Care Unit, IRCCS-Fondazione S. Maugeri, Pavia, Italy; [2]Intensive Care and Emergency Department, CTO - M. Adelaide, Torino, Italy; [3]Cardiothoracic Department, San Giovanni Battista Hospital- Molinette, Torino, Italy*

Background: Volume assured (V_{TG}) ventilation is a pressure targeted mode aimed to guarantee a target tidal volume (Vt) by varying the inspiratory pressure between two preset pressure values. V_{TG} ventilation has been used to correct sleep-related periodic hypoventilations during noninvasive ventilation (NIV). However, in this setting the likelihood of non-intentional leaks (NIL) may be high.
Aim and methods: In a bench study we wanted to assess the V_{TG} NIL compensation algorithm in three turbine driven ventilators designed to set a V_{TG} either with an EVC or with an ILC (Vivo50, Breas; PB560, Covidien; Ventimotion, Weimann). All ventilators were tested in random order using a lung simulator (Ingmar, ASL5000) in V_{TG} Pressure Control mode with both the ILC and the EVC

at three level of leaks (15, 27 and 37 l/min) and at three different conditions of respiratory mechanics: normal, obstructive and restrictive.
Results: All the ventilators in the ILC configuration were able to maintain the V_{TG} in all simulated conditions; conversely, during all simulated leak conditions when the EVC was used a significant fall both in Vt and inspiratory pressure compared to the baseline value was observed.



Conclusions: All single circuit ventilators tested in ILC configuration were able to compensate the volume loss and to ensure the preset V_{TG} in all leak conditions but failed to ensure the V_{TG} when the EVC was used.

2856
Effectiveness of the use of heliox on nebulizer associated with noninvasive ventilation in chronic obstructive pulmonary disease patients: A randomized controlled trial
Vitória Lima, Cyda Reinaux, Luciana Alcoforado, Shirley Campos, Catarina Rattes, Simone Brandão, Valdecir Galindo Filho, Armèle Dornelas de Andrade. *Physiotherapy, Federal University of Pernambuco, Recife, Brazil Saúde Matrno-Infantil, Intituto de Medicina Integral Prof. Fernando Figueira, Recife, Brazil*

Objective: To evaluate the efficacy of nebulized bronchodilators carried by heliox associated with NIV in the pulmonary deposition of radioaerosol in patients with stable COPD.
Methods: A randomized controlled trial involving 37 patients divided into four groups: heliox NIV, oxygen NIV, heliox and oxygen. For scintigraphy pulmonary inhalation dose was administered a dose of dietilnotriaminopentaacético acid labeled with technetium (99mTc-DTPA- 25 mCi) combined with fenoterol bromide(0.12 mg) and ipatropium bromide (0.25 mg) delivered through a bi-level noninvasive ventilation system using a face mask with two unidirectional valves and connected to the nebulizer for radioisotopes (IPAP = 10 cm H2O and EPAP=8 cm H2O). Images were acquired immediately after the intervention using a Gama camera and Regions of interest was determined.
Results: There was a higher radioaerosol pulmonary deposition in the lower third in the heliox NIV and oxygen NIV groups compared to oxygen group (p=0.03 and p=0.02, respectively). We observed a higher deposition in the middle third (p=0.008) in heliox NIV group when compared to O2. Thus, there was a positive correlation gain in inspiratory capacity(IC) and the total area of the right lung (p=0.04, r=0.71) in the heliox NIV group.
Conclusion: Our results suggest that coupling heliox or oxygen with bi-level NIV reached a higher lung radioaerosol deposition in the lower third for both lungs. The association between heliox and NIV seem to be more effective to promote a higher radioaerosol peripheral deposition considering the gain of the IC.
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2857
Impact of leakage on external flow measurement in non-invasive ventilation
Winfried Randerath[1], Norbert Anduleit[1], Marcel Treml[1], Christof Goebel[2].
[1]*Institute for Pneumology, University Witten/Herdecke, Solingen, Germany;*
[2]*Research & Development, Weinmann Geräte für Medizin GmbH+Co.KG, Hamburg, Germany*

Background: External flow sensors can be helpful to assess parameters such as tidal volume (VT) or minute ventilation in non-invasive ventilation (NIV). The impact of mask leakage on the reliability of those results is in question.
Methods: A NIV device (VENTImotion 2, Weinmann) was connected via standard tubing to an exhalation system (SilentFlow 2), followed by flow sensor (Hamilton Medical) and leak valve. At the end of this setup a calibration syringe (Hans Rudolph) set to 500ml VT was connected. In T mode we recorded device and flow sensor parameters. Leak (measured by NIV device) was varied from ca. 20 (leak valve closed) to ca. 70 l/min. Externally measured and device VT were compared.
Results: See Table 1.
1. With growing leak the externally measured (expiratory) VT (VTe) decreased substantially, while standard deviation increased.
2. Device VT is less leakage-dependent and more stable.

Table 1

Predetermined Leakage (l/min)	Analyzed "Breaths" (n)	External Sensor		Internal Sensor (Device)	
		VTe (ml)	%Predicted	VT (ml)	%Predicted
20	57	499±11	100±2	581±12	116±2
25	62	438±9	88±2	570±6	114±1
29	51	397±17	79±3	556±14	111±3
35	39	326±18	65±4	539±20	108±4
43	44	294±29	59±6	521±16	104±3
55	58	207±42	41±8	504±16	101±3
69	43	105±36	21±7	494±12	99±2

Conclusions: Externally measured VT is only reliable when mask leakage is minimal. Since measurement is based on airflow inside the sensor, other derived parameters are also affected. The corrected VT from the internal sensor of the NIV device is much less susceptible to leakage but tends to overestimate the actual VT in the setup we used. When exact measurements are crucial, beforehand assessment of results under controlled conditions is advisable.