

TUESDAY, SEPTEMBER 4TH 2012

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## 445. "Life's a gas": aspects of respiratory gas exchange

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**The influence of carboxyhemoglobin (COHb) generation on measured total lung diffusion capacity**

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**Background:** We found earlier that as a result of single breath diffusion capacity test for CO and NO mean relative current COHb concentration in lung capillary volume (Vc) reaches to 10% [Babarskov E. et al. ERJ 2009, v.34, suppl.53:391s].

**Aim:** To determine the influence of COHb generation on measured value of total lung diffusion capacity (DLco) and calculated Vc.

**Methods:** Dynamic balance equations of CO and COHb in alveolar and capillary volumes were solved by numerical method.

**Results:** The dependence of average relative COHb concentration on breathholding time and initial CO alveolar concentration was determined, as well as relationship between measured DLco and COHb concentration. It was demonstrated, that using of gas mixtures with usually recommended CO content (0.28%) results in COHb concentration increase to about 10%, that in turn leads to reducing of DLco about by 5% and Vc by 10%. If initial CO content in gas mixture is increased three fold (0.84%), then COHb concentration reaches to about 30%, that in turn leads to reducing of DLco about by 15% and Vc by 30%.

**Conclusion:** Our findings confirm possibility of experimental measurement of the difference between DLco values, which may be used for noninvasive investigating of lung hemodynamics. Particularly this allows to determine important diagnostic parameter - capillary blood flow rate across ventilated alveoli and correctly to calculate Vc.

4330

**How long does it take for supine TLNO & TLCO to become stable after sitting upright?**

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**Introduction:** We previously investigated (ERS Congress, 2011) the change in gas transfer for carbon monoxide (TLCO) from sitting to supine in healthy subjects, but were unable to find published studies showing how long subjects should be supine before a stable TLNO measurement could be made.

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**Method:** We measured single breath TLCO & TLNO in 13 healthy subjects (5F:8M; ages 23-57 years; mean height (SD) 1.77 m (0.10)) using a Master Screen lung function system (Jaeger Ltd, Hochberg, Germany), twice sitting at rest and then after 10, 15, 20, 25 & 30 mins respectively lying supine.

**Results:** Table 1 shows mean (SD) for TLCO and TLNO

Table 1. Absolute and percentage change from sitting to supine

Time (mins)	Sitting	Supine +10	Supine +15	Supine +20	Supine +25	Supine +30
TLCO	10.0 (2.4)	0.55*	0.58*	0.23	0.18	0.39
%Change		6%	7%	3%	2%	2%
TLNO	40.0 (8.8)	0.46	0.59	0.90	1.16	1.42
%Change		0%	2%	2%	2%	2%
TLCO/TLNO	4.00 (0.26)	-0.21*	-0.18	-0.03	0.04	-0.05
%Change		-5%	-4%	-1%	1%	0%
VA Eff (L)	6.43 (0.39)	-0.23*	-0.22*	-0.26*	-0.24*	-0.08*
%Change		-4%	-4%	-6%	-6%	-5%

Values shown as Mean (SD) TLCO in mmol/kPa/min; TLNO in mmol/kPa/min/L; VAeff in Litres.

**Discussion:** We have shown that when supine for 30 mins TLCO changes but TLNO remains stable. We confirm TLCO increases from sitting to supine but that TLNO, which reflects membrane function, remains unchanged. TLNO/TLCO demonstrates a small decrease followed by an accommodation in pulmonary capillary blood volume.

**Conclusion:** Supine gas transfer using TLNO + TLCO show physiological changes consistent with changes in pulmonary capillary blood volume when subjects lie supine. Measurements before 20 mins are transients and suggest care should be taken when making supine gas transfer estimations.

## 4331

### Fraction of exhaled nitric oxide in children aged 4 to 11 years

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**Introduction:** Fraction of exhaled nitric oxide (FENO) is a useful marker of allergic airway inflammation and can measure the response to anti-inflammatory therapy. Availability of commercial portable FENO analyzers has made the measurement more wide-spread in clinical care of children.

**Aim:** To study FENO in relation to current respiratory symptoms and medication in patients of Tartu Children's Clinic and in healthy children.

**Methods:** We measured fraction of exhaled NO with the hand-held device (NIOX MINO; Aerocrine AB, Sweden) in 242 children aged 4-11 years. Children were classified as wheezers (wheeze during the last 12 months), coughers or healthy (groups W, C and H, resp.) according to the questionnaires about respiratory and atopic problems. 79 out of 207 symptomatic children had been treated with inhaled corticosteroids (ICS) during the last month. We defined FENO values >20 ppb as abnormal, the limit suggested for children aged 12 or less by Taylor, D.R. et al. (Thorax 2006;6:817-827).

**Results:** Measured FENO values and the amount of abnormal values by groups are presented in Table 1. FENO levels were significantly higher in wheezers compared to healthy children ( $p < 0.05$ ).

Table 1. Data by groups

	H	C (no ICS)	C (with ICS)	W (no ICS)	W (with ICS)
Number (F/M)	35 (22/13)	61 (23/38)	24 (8/16)	67 (22/45)	55 (21/34)
Mean FENO (ppb)	10.6	12.4	9.8	21.7	19.2
FENO range (ppb)	2.5-23	2.5-76	2.5-26	2.5-146	2.5-90
Abnormal FENO (%)	5.7	18.0	8.3	32.8	27.3

**Conclusions:** Measurement of FENO by a portable device is feasible for children over 4 years, and can provide an objective measure of airway inflammation for monitoring of asthma in Tartu Children's Clinic.

## 4332

### Diffusing capacity > 61(%predicted) predicts absence of hypoxemia during 6-Minute Walk test in patients with interstitial lung disease

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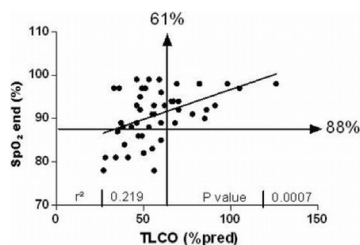
**Introduction and aim:** In patients with interstitial lung disease (ILD) the 6-minute walk test (6MWT) can be used to assess the need for supplemental oxygen during physical training and in-test hypoxemia is an indicator of poor survival. We investigated if TLCO (%pred) is a predictor for hypoxemia during 6MWT.

**Methods:** We analysed data of 66 consecutive ILD patients who performed spirometry, TLCO-measurement and 6MWT at the same day between March 2011 and February 2012. We excluded patients with pulmonary hypertension, musculoskeletal impairment, oxygen dependence and incomplete 6MWT.

Oxygen saturation (SpO<sub>2</sub>) at the end of the 6MWT  $\leq 88\%$  was considered hypoxemia.

**Results:** 48 patients were included; 33 males and 15 females, age 59 (m13 years) IPF (n=30), sarcoidosis (n=11), NSIP (n=3), CVD (n=3) and EAA (n=1).

We found a correlation between TLCO (%pred) and SpO<sub>2</sub> (%) at the end of 6MWT ( $r^2 = 0.22$ ,  $p < 0.01$ ). TLCO (%pred) >61% was determined by receiver operating analysis to be 100% specific and 43% sensitive to exclude exercise hypoxemia.



**Conclusion:** Diffusing capacity can predict hypoxemia during sub maximal exercise in patients with ILD.

Our data suggest that supplemental oxygen during exercise in ILD patients with a TLCO (%pred) >61% is not necessary.

## 4333

### Correlation between gas-exchange dynamics in recovery of exercise tests and cardiovascular parameters in pulmonary hypertension

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**Introduction:** In pulmonary hypertension (PH), cardiac dysfunction and gas exchange abnormalities within the lung may both delay the rate of recovery in O<sub>2</sub>-uptake (V'O<sub>2</sub>) and CO<sub>2</sub>-release (V'CO<sub>2</sub>) after a cardiopulmonary exercise test (CPET).

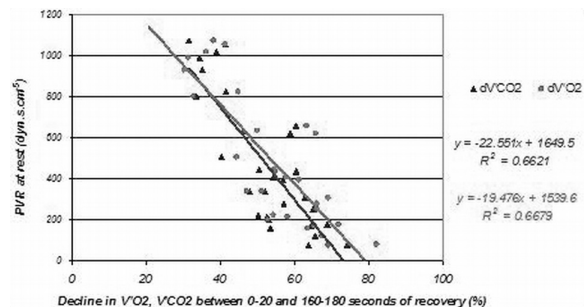
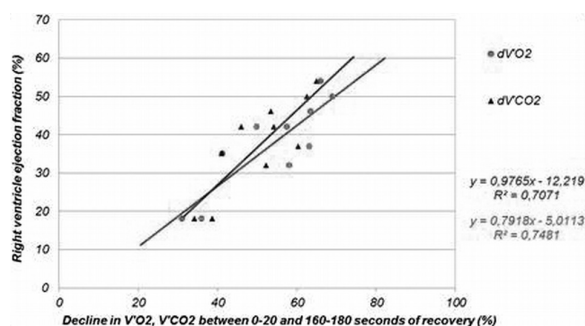
**Aim:** Determine the correlation between recovery rates of V'O<sub>2</sub>, V'CO<sub>2</sub> after CPET with pulmonary vascular resistance (PVR) and right ventricular ejection fraction (RVEF).

**Method:** In this retrospective study measurements on 12 PH-patients were used. 1-4 CPETs and heart catheterisations (for PVR measurement) per patient were done. Sometimes also a cardiac MRI was performed, rendering RVEF.

Test group characteristics

	F/M	Age (y), range	Height (cm), sd	Weight (kg), sd	FVC (% pred), sd	FEV1/VC (%), sd	PAP (mmHg)
CPET+ cath.	9/3	41 (23-59)	169 (6)	68 (11)	99 (14)	76 (5)	39 (16)
CPET+MRI+ cath.	5/1	41 (29-54)	168 (4)	63 (9)	99 (8)	92 (8)	45 (15)

**Results:** Changes in V'O<sub>2</sub>, V'CO<sub>2</sub> strongly correlated with PVR and RVEF.



**Conclusion:** In PH-patients, slow recovery-rates of VO<sub>2</sub> and VCO<sub>2</sub> are associated with a high PVR and low RVEF.

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**BTS recommendations for referral for hypoxic flight assessment are not appropriate in paediatrics**Patrick Jamieson, Colleen Carden. *Respiratory Function Laboratory, Royal Hospital for Sick Children, Yorkhill, Glasgow, United Kingdom*

**Introduction:** The assessment of paediatric hypoxia during commercial flight is not as well understood as the equivalent area in adults. The BTS recommends that patients with a baseline greater than 95% do not need a hypoxic flight assessment. This study examined the BTS criteria for referral for hypoxic flight assessment with respect to prevalence of hypoxia during this assessment, in a paediatric sample.

**Methods:** This was a retrospective audit of patients referred to a paediatric respiratory function laboratory. The test protocol used 100% nitrogen to dilute the contents of a body plethysmograph to a FiO<sub>2</sub> of 15%, before assessing the SpO<sub>2</sub> profile for 20 minutes. Failure of hypoxic challenge, according to BTS criteria, constituted a mean SpO<sub>2</sub> of less than 90% when breathing FiO<sub>2</sub> 15%.

**Results:** 107 children (58% female) age 0.1-19.2 years (mean 7.0, SD 5.4) were tested. They were referred for a variety of conditions including muscular dystrophy, cystic fibrosis, severe asthma, long term ventilation, long term oxygen therapy and sleep breathing disorders. 83% of patients referred had a baseline SpO<sub>2</sub> in FiO<sub>2</sub> 21% of greater than 95%. 29% of these patients were determined to be hypoxic in FiO<sub>2</sub> 15%.

**Conclusions:** If BTS criteria for referral were applied to this patient sample, only 6% would be detected as hypoxic in FiO<sub>2</sub> 15%. When these criteria are not used then a total of 35% of these patients are found to be hypoxic. Either the BTS criteria for detecting hypoxia are too sensitive, or the BTS indications for hypoxic flight assessment are not specific enough. This study highlights the problems associated with predicting a patient's response to hypoxia using baseline measures.

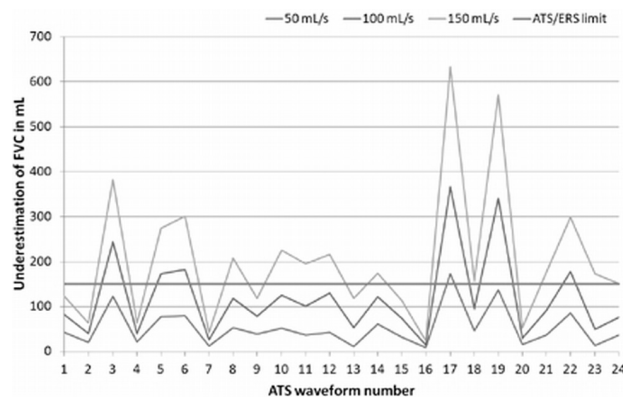


Figure 1. Underestimation of FVC at different cut off flows (the ATS/ERS repeatability limit is shown for comparison).

gently adapting the test curves to the interpolated version to avoid missing poor performing spirometers in the future.

**Reference:**

[1] Reinstaedtler J. ATS congress 2012, Abstract 31123.

4335

**Are 6MWD and FEV1 the most clinically relevant measures?**

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Six minute walk tests (6MWT) are used to assess exercise tolerance and widely used to assess the response to interventions. The six minute walk distance (6MWD) is used clinically to describe the patients' ability to tolerate exercise and is often used in comparison to FEV1. Although FEV1 and 6MWD performed concomitantly correlate, FEV1 in certain patient populations can remain stable over time whilst 6MWD can vary. Our aim was to determine if any additional lung function parameters and values obtained during a 6MWT could be used for clinical interpretation. A retrospective analysis of 312 patients who undertook full lung function, which comprised of spirometry, gas transfer and body plethysmography and a 6MWT, utilising pulse oximetry and Borg score. The correlation between 6MWD and FEV1 was  $r=0.487$ ,  $p<0.001$ . Total lung gas transfer for carbon monoxide (TLCO) was the only lung function parameter that had a stronger correlation with 6MWD  $r=0.514$ ,  $p<0.001$ . Minimum 6MWT SpO<sub>2</sub> had significant correlations ( $p<0.001$ ) with TLCO  $r=0.607$ , KCO  $r=0.521$ , TLCO % pred  $r=0.619$  and KCO % pred  $r=0.520$ . Post SpO<sub>2</sub> had significant correlations ( $p<0.001$ ) with KCO  $r=0.495$  and TLCO % pred  $r=0.501$ .  $\Delta$ SpO<sub>2</sub> had significant correlations ( $p<0.001$ ) with TLCO  $r=-0.545$  and TLCO % pred  $r=-0.542$ . The Distance Saturation Product (DSP) had significant correlations ( $p<0.001$ ) with FEV1  $r=0.552$ , TLCO  $r=0.613$ , TLCO% Predicted  $r=0.514$ . In conclusion there are several lung function parameters that correlate better with 6MWT parameters than FEV1 and 6MWD. These correlations suggest that gas transfer plays an important role in 6MWT performance. The DSP had stronger correlations than 6MWD and has the potential to be a useful clinical outcome measure.

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**Spirometer – Pass ATS/ERS test, but fail in real life**

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The 2005 ATS/ERS guidelines on spirometry recommend validating the quality of a spirometer by simulating forced expirations with computerized syringes. It was recently shown, that these test-curves have non-physiological flow spikes of approximately 150 mL/s instead of a slow drop towards the end of the expiration<sup>(1)</sup>. Spirometers vary in their minimal detectable flow, especially turbine type spirometers. Due to the spiky flow, such difference might not be detected by the current ATS/ERS waveform tests.

We used the interpolated form of the ATS curves<sup>(1)</sup> to calculate the effect on the measured FVC of the curves with varying lowest detectable flows. We evaluated flow cut-offs of 10–150 mL/s in 10 mL/s increments. Only flows that were above this cut-off were integrated for volume.

The effect on FVC was high for those ATS curves that have a low tapering end (e.g. curves 3, 17, 19), while those curves that end suddenly had small effects (e.g. curves 7, 16).

The deviations in FVC become larger than the ATS/ERS repeatability criterion even with lowest detectable flows of 50–100 mL/sec. But those failures would be missed by the currently used ATS/ERS waveforms. We recommend to ur-