

AP 01

COMPARISON BETWEEN PLETHYSMOGRAPHIC TOTAL LUNG CAPACITY (TLC) FROM HEALTHY SUBJECTS AND PUBLISHED REFERENCE VALUES

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Introduction: Reference values are fundamental for the correct interpretation of respiratory function tests. Older reference values commonly used for interpreting TLC have significant theoretical limitations. While newer reference values have been published they have not been widely validated.

Aim: To compare TLC from healthy subjects to reference values recommended by the American Thoracic Society and European Respiratory Society (ATS/ERS) (1), and newer reference values from Spain (2) and New Zealand (3).

Methods: Measurements of TLC, using a body plethysmograph and standardized techniques, were obtained from 134 (72 male, Age: 20-67 years) subjects of European origin who were never-smokers without a physician diagnosis of respiratory disease or current respiratory symptoms. The TLC difference (measured TLC minus reference TLC) and number of subjects with a TLC below the TLC 95% confidence interval (CI) lower limit for each reference set were calculated.

Results:

Reference Set	TLC Difference (L) (Mean \pm SD)	No. Subjects < TLC 95% CI Lower Limit
ATS/ERS	0.20 \pm 0.75	3
Spain	-0.39 \pm 0.75	10
New Zealand	-0.47 \pm 0.75	28

The smallest TLC difference and least number of subjects below the TLC 95% CI lower limit were obtained using the ATS/ERS recommended reference values.

Conclusion: More patients will be misclassified with a restrictive abnormality if TLC is compared to recent reference values from Spain or New Zealand.

References: 1 PhH Quanjer *et al*, Eur Respir J, 1993, 6 (Suppl. 16), 5-40.

2 J Roca *et al*, Respiratory Medicine, 1998, 92, 454-460.

3 S Marsh *et al*, NZ Med J, 2008, 119, No. 1244.

Key Words: Total lung capacity, reference values.

AP 02

FIFTEEN YEARS OF INTER-LABORATORY QUALITY CONTROL

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Introduction: National guidelines recommend that respiratory laboratories (RLs) participate in inter-laboratory quality control (ILQC).

Aim: To measure the concordance between RLs in metropolitan Adelaide and determine whether concordance changes over time.

Methods: For 15 years, pulmonary function tests were performed annually on at least one trained subject at all 13 participating RLs. Subjects were non-smokers with non-reactive airways, spanning the range of age, height and respiratory function. Equipment from Sensormedics, Jaeger, Medgraphics and Morgan was employed. Between laboratory coefficient of variation (CV%) was used as a measure of concordance. Data for each reported parameter were analysed using single factor ANOVA with time as the independent variable.

Results: Mean, minimum (Min) and maximum (Max) CV% for reported parameters over 15 years are shown with target CV% based on published laboratory intra-subject repeatability criteria.

CV%	FEV ₁	FVC	FEF _{25-75%}	DLCO _{SB}	Plethysmography			Helium Dilution		
					TLC	RV	FRC	TLC	RV	FRC
Mean	4.1	3.8	8.6	9.9	4.0	21.2	8.0	4.7	19.6	11.4
Min	2.6	2.6	4.6	6.5	0.9	9.0	4.2	2.2	4.3	4.6
Max	5.7	5.3	14.9	13.8	7.4	39.	11.1	9.6	41.5	25.3
Target	5	5	15	10	5	10	5	5	10	5

There was no significant difference in CV% over time ($p>0.05$ for all tests). For the majority of parameters, mean inter-laboratory CV% was less than target intra-subject CV%. RV and FRC for both reported methods were the most variable. Use of different predicted value sets added to the variation in reporting.

Conclusions: There is acceptable concordance between laboratories for most parameters, however concordance for outliers has not improved over time. Effectiveness of ILQC programs relies on laboratories acting on results to improve performance. A single set of predicted values should be used across the region to minimise errors in interpretation.

Keywords: Quality control, Inter-laboratory concordance.

AP 03

SHORT-TERM BIOLOGICAL CONTROL STABILITY FOR AN ULTRASONIC AND ROLLING SEAL SPIROMETER

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Introduction: Biological quality control (BioQC) is an integral component of a pulmonary function laboratory's quality assurance program. The stability of the ultrasonic spirometer's calibration is previously documented. However, there is no published data for the stability of BioQC testing. The aim of this study is to determine the stability of BioQC data on an ultrasonic spirometer.

Methods: Two healthy subjects measured their spirometry according to ATS/ERS 2005 criteria using two spirometers (EasyOne, ndd; dry rolling seal, Sensormedics (RS)) over 3 months. Mean, coefficient of variation (CV%) and the number of out-of-control messages generated by applying a multi-rule quality analysis were calculated. A 3-L syringe verification was performed prior to testing.

Results: Duplicate spirometry sessions were obtained for each subject on 39-43 occasions. CV% for FEV₁ ranged between 1.37 to 1.84 for the RS and 1.55 – 2.90 for the EasyOne. FVC CV% ranged between 1.34 – 1.74 for the RS and 2.45 – 4.15 for the EasyOne. The average difference in volume between the RS and EasyOne was -2.2% for FEV₁ and 0.3% for FVC. One systematic error violation from the multi-rule analysis was recorded in each subject on the RS over the 3 month period. No verification errors were obtained for the RS or expired flow on the EasyOne.

Conclusions: Biological data on the ultrasonic spirometer are more variable than the RS. The short-term stability (3 months) for the EasyOne spirometer is comparable to the excellent stability of the rolling seal and to the reported variability of FEV₁ and FVC. This study supports the previously reported stability of the EasyOne spirometer's calibration. The biological stability demonstrated suggests that BioQC testing would contribute to the identification of instrument errors on spirometers using ultrasound based measurement as applied by ndd TrueFlow.

Key Words: Biological Quality Control, Spirometry, Stability

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AP 04

COMPARISON OF PATIENT PREFERENCE AND DIAGNOSTIC CATEGORIZATION FOR FORCED, SLOW, AND 6 SECOND VITAL CAPACITY MANOEUVRES

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Introduction: It is assumed that stopping the spirometry manoeuvre after 6-seconds of expiration is an easier test for the patient, although this has not been formally investigated.

Aim: We investigated the diagnostic categorization, patient preference and the subjective effort required for performing spirometry using a forced, slow and six-second exhalation (FVC, SVC, and FEV₆).

Methods: Three sets of ATS/ERS standardised spirometry tests on 136 patients with either normal, restrictive or airway obstruction were performed using FVC, SVC and FEV₆ manoeuvres in a random order. Each patient identified their most preferred test and rated the effort (between 0 = least and 10 = most) for each of the three tests. We compared the difference in spirometric diagnoses using each of the vital capacity manoeuvres.

Results: The mean (SD) effort score for the most preferred test was significantly lower than the least preferred tests (5.3 (2.26) versus 6.55 (1.87) $p < 0.0001$). The restrictive patients preferred the SVC ($p = 0.045$) and the severely obstructive patients preferred the FEV₆ test ($p = 0.005$). The total group had an equal preference for FEV₆ or SVC and the FVC was the least preferred ($p = 0.00026$). The diagnostic categorisation using each of the tests showed an agreement of 88.97% between FVC versus FEV₆ and SVC versus FEV₆, the agreement between FVC and SVC was 95.59%.

Discussion: Forced vital capacity was the least preferred test while slow and six-second expirations had equal popularity. FEV₆ was the most preferred test for patients with severe obstruction, probably because they were not required to prolong their expiration.

Conclusion: This study suggests that patients prefer a shortened test when performing spirometry.

Keywords: spirometry, effort, preference, FVC, SVC, FEV₆

AP 05

STATIC LUNG VOLUMES USING THE PREFERRED OR ALTERNATE METHODS MAY BE USED INTERCHANGABLY IN THOSE WITH NORMAL OR MODERATE OBSTRUCTION ON SPIROMETRY

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The combined statement of the American Thoracic Society and European Respiratory Society in the measurement of static lung volumes (SLV) suggests that the preferred method for measuring SLV, in the body plethysmograph, following shutter closure at FRC is an expiratory manoeuvre to RV, followed by an inspiratory VC breath to TLC. The reason being, that the RV is likely to be higher using the alternate method (A) of taking an inspiratory capacity breath to TLC, followed by a VC manoeuvre to RV, particularly in airflow obstruction. The aim of this study was to identify differences between methods in FRC, VC, TLC & RV in a clinical patient group.

Methods: Consecutive patients booked for SLV measurements were invited to participate, with both methods performed in random order. Spirometry was used to classify subjects into groups. Wilcoxon Signed Rank Tests were used to assess differences between the two methods.

Results: 114 patients were recruited; 72 had paired data that met VC criteria. For the 72, there was no significant difference in FRC between methods overall. There were significant differences between methods in VC, TLC and RV ($p < 0.05$), though they are unlikely to be clinically significant (mean P-A (L) (95%CI): 0.05 (0.01-0.08), 0.08 (0.04-0.12), 0.04 (0.01-0.07) respectively). For 39 subjects with a 'normal' classification on spirometry, the results were similar to the whole group. For 25 subjects with an 'obstructive' classification (mean FEV1%Pred 63%), no significant differences were seen in FRC, VC, TLC or RV between methods (mean P-A (L) (95%CI): 0.00 (-0.04-0.04), 0.02 (-0.04-0.09), 0.06 (-0.003-0.12), 0.04 (-0.02-0.09) respectively). Only one subject changed classification between SLV methods (P: normal, A: restricted).

Conclusion: These data suggest that either the preferred or alternate method may be used to perform SLV in those with normal or moderate obstruction on spirometry as the small differences seen are unlikely to be clinically significant.

Keywords: Static lung volume measurement, testing standards

AP 06

PANTING AND RESTING MEASUREMENTS OF THORACIC GAS VOLUME BY PLETHYSMOGRAPHY ARE INTERCHANGEABLE

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Introduction: Plethysmographic determination of thoracic gas volume (Vtg) can be achieved by two measurement techniques. The panting technique requires multiple shallow breaths against a closed shutter, which can be difficult for patients to perform. The resting technique, however, consists of a single inspiratory effort, against the closed shutter, requiring less patient effort and coordination.

Aim: To determine if resting and panting measurements of Vtg measured by Vmax 6200 Autobox whole body plethysmograph (SensorMedics, USA) are interchangeable and to assess the importance of manual correction of mouth pressure vs compressed volume slopes in this cohort.

Methods: 35 consecutive patients (aged 25-82 years), referred for lung function tests were invited to participate in this study. All underwent 3-5 measurements of Vtg using both panting (60-180 bpm) and resting techniques. Vtg values were recorded before and after manual correction of slopes. The order of tests alternated between patients. All slope corrections were performed by the same scientist and results of one technique were corrected blinded to those of the other. Bland-Altman analysis was used to assess the agreement between the two techniques.

Results: 5 subjects were excluded due to uninterpretable resting Vtg results. For the remaining 30 subjects, no significant difference (Mean Difference = 20 mL (1.7%), (95% CI = -480 mL to +530 mL) was seen between resting and panting Vtg measurements after slope correction. Prior to slope correction the mean difference between techniques was 10 mL (1.6%), (95% CI -880 mL to +890 mL). The variance from the mean Vtg of the 3-5 efforts were: 1.85% (slopes corrected) and 8.38% (slopes uncorrected) for the panting technique, and 2.85% (slopes corrected) and 12.1% (slopes uncorrected) for the resting technique.

Conclusion: These data confirm that resting and panting techniques may be used interchangeably for plethysmographic determination of Vtg. Manual slope correction is not only essential for clinical acceptability but also to satisfy ATS/ERS guidelines (i.e. variability <5% from the mean Vtg).

Key words: Plethysmograph, thoracic gas volume, slope correction

AP 07

COMPARISON OF 6-SECOND AND 10-SECOND BREATH-HOLD METHODS FOR THE MEASUREMENT OF DLCO IN PATIENTS WITH DIFFERENT VENTILATORY FUNCTION PATTERNS

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In clinical respiratory function laboratories, some patients are too dyspneic to perform a breath-hold manoeuvre for the required period, usually 10 seconds, for a standard single-breath DLCO test. The aim of this study was to investigate the effect of shortening the breath-hold time to 6 seconds on DLCO in patients with different ventilatory function patterns.

Methods: The measurements of DLCO with 6-second breath-hold (6sBH) and 10-second breath-hold (10sBH) methods were performed in a randomized order in 56 patients with normal, obstructive or restrictive ventilatory function, using Jaeger Masterscreen PFT devices which analyzed mixed expired alveolar samples and applied the Jones-Meade method to determine the effective breath-hold time.

Results: All the DLCO measurements met ERS/ATS reproducibility criteria. Mean (SD) values are presented in the table (DLCO unit: ml/min/mmHg).

Patient group	Normal n=20	Obstructive n=20	Restrictive n=16
FEV1 (%pred)	105.8 (8.9)	47.8 (20.8)	68.1 (13.4)
DLCO (by 10sBH method)	23.3 (7.1)	12.1 (4.3)	11.4 (5.1)
DLCO (by 6sBH method)	24.2 (7.1)	12.5 (4.4)	12.0 (5.4)
DLCO (%pred) difference (6s-10s)	3.4 (3.0)	1.6 (3.9)	2.3 (2.0)

Paired t tests revealed a significant difference ($p < 0.001$) in DLCO between the two methods in the normal and restrictive groups; a significant increase in KCO and decrease in VA in all the groups in the 6sBH method. The Bland-Altman analysis showed the 95% limits of agreement between the two methods were within -1.5 to 2.6 ml/min/mmHg in DLCO and -7 to 10% in DLCO(%pred) in all the groups.

Discussion: Although an increase in DLCO by the 6sBH method was observed in all the groups, this change was within the acceptable variability and appeared to be clinically insignificant. We suggest that the 6sBH method could be an alternative for the patients who are unable to complete the standard DLCO test.

Key Words: DLCO, Breath-hold time

AP 08

CORRECTION OF TLCO FOR CARBOXYHAEMOGLOBIN ALTERS CLASSIFICATION OF SEVERITY OF DYSFUNCTION

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Aim: To assess the clinical impact of correcting TLCO for Carboxihaemoglobin in patients with a smoking history.

Method: A retrospective analysis of data collected during routine lung function and blood gas analysis. All TLCO measurements met the ATS/ERS 2005 criteria for acceptability and repeatability. Blood analysis was performed within 15 minutes of TLCO measurement using an analyser (Radiometer ABL520) accredited by NATA for Haemoximetry. Smoking status was recorded in all subjects. Results for TLCO were corrected for total Haemoglobin and a second set of data corrected for both total and Carboxihaemoglobin, then classified for severity according to ATS/ERS 2005 guidelines.

Results: Data were collected on 107 patients (M:F 61:46), as 29 never, 62 past and 16 current smokers. Median pack year history was 29 in the current smokers and 25 for past smokers. Median TLCO, Hb, COHb. Mean shift in TLCO was small but significant for smokers but not past or non-smokers. 5 patients increased severity according ATS/ERS interpretation criteria with the greatest proportion in the current smokers group.

Smoking	n	TLCOc	TLCOc _(COHb)	p	n shifted severity	Median COHb
Current	16	17.3	16.6	<0.05	2	4.3
Past	62	14.8	15.0	NS	2	2.3
Never	29	20.2	19.9	NS	1	2.2

Conclusion: In current smokers correction of TLCO for HbCO increased the severity ranking of 12.5% of patients and was significantly less than the value corrected for Hb alone. In past and never smoked severity was increased in only 3.3% and was not significantly different from TLCOc. TLCO should be corrected for both measured total Hb and COHb at time of test.

Discussion: Whilst we have demonstrated a change in clinical severity in current smokers it is unclear what impact this may have on guiding intervention therapy.

AP 09

FINGER PRICK HAEMOGLOBIN SAMPLING ADDS SIGNIFICANT UNCERTAINTY TO CORRECTED DLCO_{SB} MEASUREMENTS

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Introduction: Haemoglobin concentration (Hb) is used to correct DLCO_{SB}. Finger prick samples are commonly employed for Hb measurement using point-of-care devices such as Hemocue™. This study aims to determine the variation in Hb measurement when taken by finger prick and the potential effects on DLCO_{SB} results.

Methods: On two occasions 4 subjects had 8 finger pricks and a venous blood sample taken. All samples were taken by a single staff member and analysed on a haemoglobinometer (Hemocue 201+, Hemocue Australia) strictly according to the manufacturer's instruction. Finger prick Hb was compared to venous blood Hb which was analysed on a blood gas analyser (ABL725; Radiometer, Copenhagen). ANOVA and Student t-tests were used to compare Hb measurements. The coefficient of variation (CV%) and maximum variance from the session mean were used to describe the spread of measurements.

Results: In terms of measured Hb, there was no significant difference between subject, site, session, sample type (venous 133±4.6 g/L (SD, n=16) or finger prick 133±5.7 g/L (n=64)) or analysis method (Hemocue 133±4.1 g/L (n=72) or blood gas analyser 133±4 g/L (n=8)) (p>0.10 for all tests). When the same venous sample was analysed multiple times with the Hemocue™, the mean within-subject CV was 1.5% compared to 4.4% for multiple finger prick samples from the same subject. For multiple finger prick samples, the maximum variance from the session mean averaged 7.2% (9.7 g/L).

Conclusions: Hemocue was accurate compared to a blood gas analyser in this group. However, the finger prick was less precise than a venous sample, adding approximately 3% to the CV% with the maximum error of any one sample being approximately 7%. This error likely arises from sampling technique and when a single finger prick Hb is used to correct DLCO_{SB} it may add considerable uncertainty to the final result.

Keywords: DLCO_{SB}, Haemoglobin correction

AP 10

PREVALENCE OF COPD IN HEALTHCARE WORKERS WHO ARE CURRENT OR PAST SMOKERS

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Aim: To assess the prevalence of COPD in staff with a history of past or present cigarette smoking in a tertiary teaching hospital.

Method: As part of the promotion of World COPD day 2008, staff at the Austin Hospital Heidelberg who were current or past smokers were offered spirometry to assess their lung function. Over one day 79 staff performed spirometry according to ATS/ERS standards. Smoking status and pack year history, age, height, gender and a brief respiratory history were recorded. Other staff members with no smoking history were included if they had other COPD risk factors, eg dust exposure. The incidence of COPD based upon GOLD spirometry criteria (FER<0.7) were recorded for each group.

Results: Results from 72 of 79 tests that met ATS/ERS criteria were analysed. When tobacco exposure groups are combined, 25% of subjects who were either current or past smokers demonstrated evidence of COPD on spirometry.

Smoking status	n	M:F	PkYear#	Age#	COPD
Current	30	6:24	16.6	47.5 (37-55)	5
Past	31	10:21	15.0	51.0 (41-55)	10
Never	18	3:15	-	54.5 (34-59)	5

#Median (inter-quartile range)

Conclusion: The prevalence of COPD in health workers with tobacco exposure is slightly higher than that quoted in the literature (Access Economics, 2008) and probably reflects a selection bias. The prevalence in those that never smoked was linked with other risk factors for COPD.

Discussion: There was a gender bias in our sample, we feel this reflects the gender bias of healthcare employees. Health employers should be encouraged to promote support for staff that wish to quit. Many staff had already quit smoking. Whilst we have demonstrated a change in clinical severity in current smokers it is unclear what impact this may have on guiding intervention therapy.

AP 11

NORMAL RESTING GAS EXCHANGE DOES NOT EXCLUDE A SIGNIFICANT SHUNT AS MEASURED BY THE 100% OXYGEN TECHNIQUE

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Introduction: Intra-pulmonary or intra-cardiac right to left shunting is one of the possible causes for hypoxaemia. The 100% oxygen technique measures shunt by determining the proportion of cardiac output not in direct contact with the alveolar-capillary membrane. The aim of this study was to investigate whether a normal PaO₂ or normal gas exchange (A-aPO₂ gradient) at baseline excludes a significant shunt as measured by the 100% oxygen technique.

Methods: Data was examined from 166 patients (147 liver transplant work-up) who had baseline arterial blood gases measured on room air immediately prior to estimation of shunt using the 100% oxygen technique.

Results:

		Shunt?	
		Yes	No
Normoxic?	Yes	27	94
	No	18	27

		Shunt?	
		Yes	No
A-aPO ₂ >15 mmHg	Yes	36	54
	No	9	67

Of the 45 patients with significant shunt, 60% were normoxic and 20% had normal gas exchange at baseline.

Conclusion: A normal baseline PaO₂ or alveolar-arterial oxygen gradient does not exclude a significant shunt (above the upper limit of normal) as measured by the 100% oxygen technique.

AP 12

MEASUREMENTS OF ACINAR VENTILATION AFTER LUNG TRANSPLANTATION

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Long-term survival of lung transplant patients is limited, principally because of Bronchiolitis Obliterans Syndrome (BOS). Currently BOS status is diagnosed on the basis of spirometry however other more sensitive techniques based on small airway function have been proposed. This study assessed the ability of the Multiple Breath Nitrogen Washout test (MBW) to discriminate changes in ventilatory inhomogeneity of the acinar region of the lung in transplant patients. Also to detect changes in acinar heterogeneity within 6 months post transplant. 75 double lung transplant patients with varying degrees of BOS were recruited. MBW was performed alongside spirometry during outpatient visits. Correlation analysis was used to test the relationship between the MBW parameters, Scond and Sacin and BOS status. A strong correlation was found between Sacin ($r = 0.706$, $p < 0.01$) and BOS status, while the correlation between BOS status and Scond was relatively weak ($r = 0.155$, $p < 0.05$). Patients with BOS status 0, in the first 6 months of transplantation had a significantly higher Sacin $0.165 \pm 0.080 \text{ L}^{-1}$, $p < 0.001$ than the normal healthy population $0.102 \pm 0.015 \text{ L}^{-1}$ and a significantly lower Scond $0.021 \pm 0.018 \text{ L}^{-1}$, $p < 0.001$ (Controls $0.028 \pm 0.005 \text{ L}^{-1}$). Sacin in transplant patients 6 months after transplantation with BOS status 0, was significantly higher than the normal population ($p < 0.001$) and also the patients recorded in the first 6 months after transplantation ($0.231 \pm 0.140 \text{ L}^{-1}$, $p < 0.006$). In conclusion we have demonstrated significant heterogeneity of acinar ventilation in patients following lung transplantation. Importantly the changes in Sacin were related to BOS staging.

Funding source: AIRmed.

Conflict of interest: No.

AP 13

EARLY INHOMOGENEITY OF CONDUCTIVE VENTILATION POST LUNG TRANSPLANT IS ASSOCIATED WITH LUNG REPAIR

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Lung transplantation is regarded as an effective treatment for people with end-stage lung disease. We have previously demonstrated significant ventilation heterogeneity in the acinar region of the lung in patients following lung transplantation. A possible cause of the increased ventilation heterogeneity during this period is injury associated (ischemia-reperfusion, allograft rejection, infection) dysregulated airway repair processes. Clara cells and their major secretory protein CC10 are predominantly responsible for bronchio-alveolar repair. Double lung transplant patients were studied 1 and 3 months post surgery. Each patient had measures of spirometry and acinar and conductive measures of ventilation heterogeneity from the multiple breath washout technique for Nitrogen (MBW). Clara cell protein (CC10) and IL-8 (as an injury marker) were also estimated from BAL taken at the time of the pulmonary function measures. Results: 39 patients were recruited. The mean S_{acin} was $0.137 \pm 0.079 L^{-1}$ and S_{cond} was $0.023 \pm 0.012 L^{-1}$. There was no significant relationship between CC10/IL-8 ratio and either S_{cond} or S_{acin} at 1 month post surgery. However there was a small but significant relationship between S_{cond} and CC10/IL-8 ratio 3 months post surgery ($r^2 = 0.18$ $p < 0.05$). In conclusion ventilation heterogeneity in the conducting airways is partly related to a marker of lung repair in patients 3 months following lung transplantation.

Funding source: NHMRC.

Conflicts of interest: None

AP 14

A METHODOLOGY TO DESCRIBE AIRWAY COMPLIANCE AS A 3-DIMENSIONAL SURFACE

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Background: To assess respiratory function in detail, in vivo airway compliance, which is airway size specific must be evaluated. Currently, only discrete methods of airway compliance analysis have been described.

Aim: To develop a methodology that enables in vivo airway compliance, specific to airway size, to be described as a continuous 3-dimensional surface.

Methods: 8 patients with doctor diagnosed asthma underwent partial HRCT scans at FRC, TLC and a midway point (MID). Airways were identified in consecutive scans via branch point analysis. Mean lumen and wall areas were measured from automated analysis software and airway lumen diameter (DI) determined. DI measurements at MID and TLC were normalised to the DI measured at FRC. Normalised DI at MID and TLC were plotted against DI at FRC and exponential equations were fitted. By combining these equations with transpulmonary pressure-volume curves a 3-dimensional description of airway compliance, specific to airway size, was obtained.

Results: In vivo airway compliance is greatest in the small airways (DI<3mm). Small airway DI increases by 79.4% from FRC to TLC, where only 27% of that increase occurs between FRC and MID. Large airways (DI>8mm) are less compliant, increasing in DI by only 12.4% between FRC and TLC, where 41% of that increase occurs between FRC and MID.

Conclusion: We have described a unique methodology to determine a 3-dimensional representation of in vivo airway compliance which is specific to airway size. Small airways are much more compliant than large airways, but large airways reach their maximum DI at lower lung volumes. This novel three dimensional surface representation of compliance may be a unique tool for future drug efficacy studies.

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Conflict of Interest: No

AP 15

MONITORING INDIVIDUAL POLLUTANT PARTICLE BEHAVIOR ON INTACT LIVE AIRWAYS USING SYNCHROTRON X-RAY IMAGING

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The behaviour of particles on the airway surface after deposition is likely to influence their effects on lung health. In airways of anaesthetised mice we have begun to examine the motion of selected pollutant particles along the airway wall using synchrotron phase-contrast x-ray imaging (PCXI).

Methods: Nasal and tracheal airways of nembutal-anaesthetised hairless mice were imaged on the BL20XU beamline at the SPring-8 synchrotron in Japan. Quarry-dust, asbestos, fibreglass, lead (galena) particles and (reference) hollow glass beads were suspended in distilled water and instilled into the airways and images were captured every 5 seconds. Motion-detection was applied to the image sequences to reveal the behaviour of particles otherwise undetectable in raw images.

Results: All 5 particle types could be detected transiting along airway surfaces after instillation, with lead particles the most obvious, and quarry dust the least visible. Time lapse movies showed that individual asbestos and fibreglass fibers as well as agglomerations of some particles were apparent. Particle transit behaviour was heterogeneous, did not always follow linear paths, and clumps of particles could be seen to move along airways. The mean transit rate in the nasal airway for glass beads was 0.2 mm/min (SD 0.04). In the tracheal airway transit was measured at 1.0 mm/min (SD 0.89). Transit rates for remaining particles await completion of specialized image-processing routines.

Conclusion: It is now possible to non-invasively image individual particle MCT in live mouse nasal and lower airways using synchrotron PCXI. The transit rate of glass beads is consistent with published murine MCT values, given barbiturate anaesthesia. This study demonstrates the novel potential of PCXI for monitoring particle deposition and transit along airways.

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AP 16

FLOW-DEPENDENCE OF ANATOMICAL DEADSPACE - WITHIN AND BETWEEN SESSION VARIABILITY

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Introduction When anatomical dead space (VD) is measured over a range of expiratory flows using a gas washout method, two indices can be obtained: 1) the flow-dependent component of VD, which reflects non-uniform ventilation, and 2) the flow-independent component, which is a measure of the 'true' luminal volume of the airways, not confounded by expiratory flow. This study aims to determine the within and between session variability of these new measurements.

Aims: To determine the within and between session variability of the flow-dependent and flow-independent components of VD.

Methods: VD was determined in triplicate by gas washout (molar mass and volume) using an ultrasonic sensor (nidd Medizintechnik AG) on 4 subjects (19-25 yrs, 3 male) over a range of expiratory flows (~0.2-4.0 L/s) at three levels of lung inflation (near RV, FRC and TLC). The VD measurement was repeated three times on the same day (within session) and on four consecutive days (between session). The flow dependency of VD was measured as the slope of the relationship VD vs flow at RV, FRC and TLC.

Results: The average within session coefficient of variation for VD for all subjects for each of the three lung volumes was FRC 6.1%, TLC 8.7% and RV 6.5%. The average between-session coefficient of variation for the flow-dependent component of VD over the three days of testing was FRC 14.8%, TLC 12.0% and RV 13.2% and for the flow-independent component was FRC 16.8%, TLC 14.0% and RV 15.2%.

Conclusion: These preliminary results indicate that the measurement of VD and the flow-dependent and flow-independent components are repeatable both within and between test sessions.

Key words: Flow-dependence of dead space, VD, variability

AP 17

PERCEPTION OF INDUCED ACUTE BRONCHOSPASM IN ELITE ATHLETES

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Introduction: Elite athletes may suffer significant exercise-induced bronchospasm (EIB) and poor perception of associated symptoms is not uncommon in both athletes and sedentary subjects. The aim of this study was to investigate the ability of elite athletes to perceive the severity of bronchospasm after provocation by Eucapnic Voluntary Hyperventilation (EVH).

Methods: Seventy-four consecutive elite athletes presenting for provocation tests for assessment of EIB performed a 6-minute single-dose EVH challenge test. The standard Modified Borg Scale was used to assess perceived breathlessness 30 seconds prior to performing spirometry manoeuvres at each specified time post EVH challenge. The relationship between the Borg score and the greatest fall in FEV1 post-challenge was examined using regression correlations.

Results: Subjects: Seventy-four elite athletes, 60 male and 14 females. Age = 23 ± 5.9 years. Baseline measurements: FEV1 %Pred = 108 ± 12.07 , FVC %Pred = 111 ± 13.10 (mean \pm SD). Thirty-four subjects (46%) demonstrated a positive response to EVH. There was a significant linear correlation between greatest fall in FEV1 and perceived breathlessness ($r = 0.47$, $p = .005$). There was a wide spread of Borg scores for subjects with falls in FEV1 from 10-20%, with a far tighter correlation in those with responses greater than 20% ($r = 0.67$, $p = 0.03$).

Conclusion: Although there is a correlation between change in FEV1 and symptoms in athletes with a positive response to EVH, symptom perception is a reliable marker only in those with a fall in FEV1 greater than 20%.

Key Words: Perception, EIB, EVH

AP 18

THE 'NORMAL' RESPONSE TO A HYPOXIC ALTITUDE SIMULATION TEST

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Introduction: There are an increasing number of patients with respiratory disease who wish to travel by air and clinician awareness of the hazard of air travel has also increased. Recommendations for patients who may be at risk during air travel include a Hypoxic Altitude Simulation Test (HAST) and referrals have increased accordingly. The aim of this study is to assess the 'normal' response to a HAST and establish normal values to assist in making recommendations for patients with respiratory disease wishing to fly.

Methods: Twelve healthy adult (aged 20-60, 6 females and 6 males) volunteers were recruited for the study. Pulse oximetry (SpO₂) was measured continuously. Subjects' breathed a hypoxic gas mixture of 15% FiO₂, balance Nitrogen (N₂) for 15 minutes. The hypoxic mixture was delivered using a high flow venturi mask driven by 100% N₂. The FiO₂ of 15% is equivalent to 8,000-10,000 feet altitude, the cabin pressurization of a commercial aircraft.

Results: Baseline SpO₂ before the HAST was $99 \pm 1\%$ and after 15 minutes on hypoxic gas mixture SpO₂ was $89 \pm 5\%$. Time course of SpO₂ showed an abrupt fall during the first minute to $95 \pm 4\%$, with a further decrease at 7 minutes ($89 \pm 5\%$). From 7 minutes to 15 minutes SpO₂ showed no clear trend within a range of 88-90%. One individual's SpO₂ continued to fall whereas another increased at 15 minutes.

Conclusion: This study has demonstrated significant desaturation in normal adults during a HAST, with some individuals showing falls similar to that seen in many patients who are ultimately recommended supplemental oxygen. The clinical significance of the decrease in SpO₂ with HAST in some patients may need further examination.

Key words: Hypoxic altitude simulation test, saturation, gas mixture.

AP 19

ASSESSMENT OF THE ON-BOARD PRACTICES OF AIRLINES FOR PASSENGERS REQUIRING OXYGEN DURING AIR TRAVEL

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Introduction:

Modern aircraft cruise at altitudes of up to 41000ft (12,500m), where the cabins are pressurised to the equivalent of up to 8000ft (2,500m). This results in reduced barometric pressure and hence a decrease in partial pressure of oxygen from 98mmHg to 55mmHg at 8000ft. This is equivalent to breathing 15% oxygen at sea level. Therefore predisposed individuals with lung disease may be at risk of hypoxia and may need supplemental oxygen on board the aircraft.

Aims: To determine the current practices of carriers of air passengers requiring in-flight oxygen.

Methods: A list of international airlines departing from Sydney Kingsford-Smith Airport was obtained from the website <http://www.sydneyairport.com.au>. Searches were conducted for "oxygen", special needs/requirements, services, medical conditions or for any information and policies on oxygen use on each of the Airline's website. The information collected included: type of oxygen delivery on board; cost and fees involved; medical authorisation requirements; flows; cylinder size; suppliers; reservation notice and contact details as well as any additional information.

Results: Forty one airlines were identified. Only 17 provided information regarding on-board oxygen use. 4 of these allow passengers to bring their own oxygen, 15 supply on board oxygen, 9 allow use of approved Personal Oxygen Concentrators (POCs). All airlines need medical clearance and specified forms completed. 13 airlines state additional charges are required, 5 of these specify fees involved. One airline supplies oxygen for free. Charges range from \$100 to \$250 per bottle; some require deposits; others charge 100-150% of full fare plus oxygen tank fee. 48hrs is the most common timeframe to notify the airline of oxygen requirement however this varies from 36hrs to 7 days.

AP 20

ASSESSING THE ACCURACY OF THE HYPOXIA CHALLENGE TEST TO PREDICT IN-FLIGHT HYPOXIA IN INFANTS

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Introduction: The hypoxia challenge test (HCT) is used to assess fitness to fly in patients with respiratory disease. The HCT has shown to replicate in-flight hypoxia in adults (1), but in newborn infants has demonstrated to be inaccurate (2). The aim of this study was to determine the accuracy of the HCT in predicting in-flight hypoxia in pre-term and healthy term infants.

Methods: One week prior to air travel the infant underwent a HCT. This involved inspiration of 14% oxygen (O₂) at 15L/min via a face mask for 30 minutes, with continual monitoring of SpO₂ and heart rate (HR). If during the HCT or in-flight the premature infant desaturated below 85% for >2 minutes supplemental O₂ was applied via nasal cannulas and titrated to achieve \geq 94% saturation. An infant was considered to have passed the HCT if SpO₂ was maintained above 85% for thirty minutes. In-flight, parents were given a portable oximeter (Nonin PA3100 WristOx or a 2500A PalmSat) and were instructed to record SpO₂, HR and the infant's behavioural state (e.g. awake, asleep) every 15 minutes.

Results: Thirteen infant's, 5 premature (median age 39.16 weeks corrected) underwent a HCT and successfully undertook in-flight monitoring. All 13 infants passed the HCT and were identified as not requiring oxygen in-flight. Based on the in-flight recordings 2 infants (1 born at term) were identified as requiring oxygen in-flight. On the data collected to date the accuracy of the HCT in infants is 85%.

Conclusion: Based on these preliminary data the HCT accurately predicts an infant's response to in-flight hypoxia in the majority of children. Further study numbers are needed to allow for a detailed analysis of the ability of the HCT to determine in-flight hypoxia in infants.

References: 1: BTS Standards of Care Committee. Thorax, 2002; 57(4):289-504.

2: Resnick, S.M et al. Chest 2008; 133:1161-1166.

Keywords: Hypoxia challenge test, infant, SpO₂, in-flight.

AP 21

ALTERED LUNG FUNCTION IN CHILDREN BORN WITH BRONCHOPULMONARY DYSPLASIA: A PILOT STUDY

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Introduction: Bronchopulmonary dysplasia (BPD) is a chronic lung disease associated with preterm birth. The lung pathophysiology in school-age children following BPD in the era of treatment with surfactant, antenatal steroids and minimally invasive ventilation is not well described. This study aimed to quantify the respiratory function of children aged 9-11 years born prematurely with BPD.

Methods: Children aged 9-11 years born <32 weeks gestation with a neonatal diagnosis of BPD were recruited. Lung function was assessed using the forced oscillation technique (FOT), lung volumes (multiple breath washout), exhaled breath temperature, spirometry, DLCO, cardiopulmonary exercise testing and a 3 slice high-resolution CT scan of the chest. Here we present preliminary results from FOT, spirometry and DLCO. Results were compared with 21, age and height matched healthy children from a local cohort.

Results: 12 children have been studied (6 male). Mean (SD) FOT Z scores for BPD and healthy cohorts were not significantly different (t-test: $p>0.05$). Spirometry was significantly lower in children with BPD ($p<0.015$) with mean (SD) Z scores for BPD and healthy being FEV1 -1.63 (0.73) and -0.06 (0.80); FVC -0.76 (0.86) and 0.36 (0.94); FEF25-75% -2.05(0.76) and -0.62 (0.75); and FEV1/FVC-1.51(0.77) and -0.67 (0.75). Children with BPD had reduced mean (SD) DLCO 13.85 (2.48) mL/mmHg/min compared with healthy children (16.25 (2.59); $p=0.023$) as well as reduced volume corrected DLCO (DLCO/VA: 5.16 (0.69) and 5.74 (0.51); $p=0.033$).

Conclusions: These preliminary results support the hypothesis that an arrest of peripheral lung development associated with premature birth results in lowered spirometric and diffusing capacity measurements in children aged 9-11 years.

Key Words: Bronchopulmonary dysplasia, preterm, children, respiratory function

AP 22

LOOKING INTO THE FUTURE OF DOMICILIARY OXYGEN

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Introduction:

The role of domiciliary oxygen is well established. The oxygen concentrator has largely superseded the use of cylinders within the home environment. A more recent development is the portable concentrator (POC). POCs are lightweight, battery operated and approved by many national and international airlines for travel; features of interest to many patients requiring portable O₂.

Aim: To compare a POC with portable cylinder oxygen.

Method: The Eclipse concentrator (EPOC) was used. Ten patients on long term domiciliary oxygen were recruited. Each patient performed 2 step tests according to laboratory protocol. The patient used prescribed rates of O₂ via the EPOC for one test, and used cylinder oxygen via conserved device for the other test.

- Order of test was randomised to use EPOC or cylinder O₂ first.
- Patients were asked to step up and down a 9, 12, or 16 cm step according to ability until exhaustion or 6 minutes, whichever was shorter.
- Time exercised, number of steps, oximetry before during and after exercise, and time to recover pulse rate were recorded.
- Borg scale was used to estimate breathlessness and leg fatigue.

Results: There were no differences in SpO₂ at commencement and end exercise, the time exercised, number of steps, time to recovery or subjective assessments between the EPOC and the cylinder oxygen.

Discussion: The laboratory step test adequately mimics the daily activities of patients. Costs are comparable when the need for a concentrator, cylinder holding, and deliveries are taken into account.

Conclusion: These favorable results suggest the POC marks the beginning of a new era for patients requiring domiciliary O₂.

Key words: Domiciliary, oxygen, portable concentrators

AP 23

A REVIEW OF INFECTION CONTROL PROCEDURES IN RESPIRATORY LABORATORIES AND WARDS IN NSW

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Introduction: This survey was performed to determine the infection control procedures currently being used for respiratory equipment in hospitals and respiratory laboratories and to assess these procedures against the most recent NSW Health Infection Control Policy.

Methods: A survey was sent to respiratory laboratories via ANZSRS (NSW Branch) and hospital respiratory wards via the Respiratory Nurses Interest Group (NSW) in order to assess the process and frequency of cleaning for a range of both non-critical and semi-critical respiratory equipment. It is standard under the current policy that equipment that comes into contact with mucous membranes requires a minimum of high level disinfection for cleaning. The survey also assesses compliance on mouthpieces, cleaning areas and staff training practices.

Results: The study population involved 23 facilities; 13 laboratories and 10 wards. The process of cleaning showed a 50% compliance rate, assessed against the NSW Health Infection Control Policy, with the majority of respiratory equipment compliance being for those instruments classified as non-critical (50%) and a further 32% being single patient use items. The frequency of cleaning found only 43.5% of facilities to be compliant, with 52% of this total being semi-critical items. A designated cleaning area was present in 52.4% of facilities. Staff are reported to be trained in cleaning and processing of equipment, however, only 30.4% of facilities keep records of competency and training. The highest compliance from the study was shown in Material Safety Data Sheets (MSDS) and Safe Work Practices (SWPs) with 87% of facilities compliant with OH&S practices.

Conclusions: A review of infection control practices for respiratory equipment across laboratories and wards in NSW is essential to ensure practices follow the NSW Health Infection Control Policy.

Keywords: infection control, semi-critical, respiratory equipment