S1

SURGICAL ASPECTS OF LUNG TRANSPLANTATION

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The transplantation of thoracic organs was pioneered for hearts at Stanford University Hospital by Lower and Shumway in the early sixties. There were many obstacles to overcome and when this became accepted therapy, the stage was then set for developing lung transplantation. Reitz and Shumway developed the first technique for lung transplantation using the lungs attached to the heart as a single organ block. Joel Cooper at Toronto General Hospital developed a fundamentally different approach using single-lung or double-lung transplantation. Single-lung transplantation or bilateral sequential single-lung transplantation (double-lung transplant using the left and right lungs as separate organs) has become proven therapy for respiratory failure.

The conditions commonly referred for lung transplantation are Emphysema, Bronchiectasis (Cystic Fibrosis) and pulmonary fibrosis. Conditions requiring heart-lung transplantation are congenital heart disorders with Eisenmenger syndrome or cardiac failure with irreversible pulmonary hypertension. The selection of patients suitable for transplantation requires assessing the rate of deterioration of the current condition and the quality of life and the likelihood of obtaining a suitable donor. The recipients who had previous thoracic surgery were initially not considered because of the risk of post-operative death from blood loss.

The use of improved organ preservation techniques and the demand for liver, kidneys pancreas, heart and lungs has resulted in the procurement operation occurring remotely from the recipient operation. Organs from as far away as Perth or New Zealand can be transplanted in Sydney. The surgical techniques of bronchial or tracheal anastomosis and the haemodynamic support of the recipient have evolved to the point where the operation can be performed on or off cardiopulmonary bypass depending on the stability of the recipient during the operation.

Lung transplantation is proven therapy for respiratory failure. The challenges remain to improve survival and increase the donor rate, as there are more potential recipients than donors. Alternate strategies such as living related donors or new approaches to stenting and treatment of Emphysema are ongoing. The medical management of the post-operative patient is demanding and survival is slowly improving with improvements in immunosuppression and the treatment of post-operative complications.

S2

LUNG TRANSPLANTATION: A RESPIRATORY PHYSICIAN'S PERSPECTIVE

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Lung transplantation (LTx) is a well-established therapy for end-stage lung disease but is limited mainly by donor availability in our country. The first successful survivor of LTx in the modern era of cyclosporin therapy was transplanted in the United States of America in 1981 with the first LTx in Australia in 1986. There are three centres performing LTx in Australia with a total of 70-85 procedures per year. One-year post LTx survival is now close to 90% in Australia in comparison to the benchmark of 73% reported in the International Society of Heart and Lung Transplantation Registry (ISHLT). Furthermore, five-year survival is 56% (ISHLT 45%) and ten year survival is 40% (ISHLT 23%). The commonest indications for LTx in Australia are chronic obstructive pulmonary disease (COPD), cystic fibrosis (CF) and pulmonary fibrosis. Patients on the waiting list with pulmonary fibrosis have a high mortality reflecting the need for early referral in this condition. Outcomes of successful LTx are related to the procedure, the underlying disease and sequelae of chronic disease. The ISHLT reports a survival benefit for LTx for COPD at one year in comparison to all other conditions, whereas at five years those with CF have a significantly higher survival rate. The 5 and 10-year survival rates reported post LTx for CF in Australia are 61% and 55%, respectively. Although lung function improves to an FEV_1 of ~75-85% for double lung transplant recipients and 55-70% for single lung transplant recipients, there remains a marked reduction in VO_2 max most likely related to muscle dysfunction as a consequence of chronic disease and deconditioning. Early mortality and morbidity are largely related to infection and early graft dysfunction. Long-term survival is limited by bronchiolitis obliterans syndrome (BOS) and chronic infection. Fifty percent of 5-year survivors are reported to have BOS; a clinical syndrome defined by a fall in lung function from best post LTx values. Prevention and treatment of BOS remains the greatest challenge facing LTx, and Australian centres are currently involved in several large international multi-centre randomised trials targeting this condition. In addition to recent developments in new immunosuppressive agents there are now better management strategies for traditional agents targeting renal dysfunction which occurs in 38% of long-term survivors with 4.3% progressing to end-stage renal failure requiring dialysis or transplantation. Long-term survival depends on diligent monitoring of the patient and a close relationship between the patient and the transplant team.

S3

LUNG TRANSPLANTATION: WHAT CAN GO WRONG?

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The development of lung transplantation as a viable therapeutic modality has been hindered by a surfeit of demand over supply of donor resources. Hence, most programmes report a predictable mortality on the active waiting list of 15-25%. Patients with pulmonary fibrosis, unexplained pulmonary hypertension and cystic fibrosis have the highest mortality on the waiting list, while patients with emphysema have the lowest. To minimise the effect of the lack of donors within Australasia, active strategies to manage the potential lung donor have been undertaken so that now, 40-45% of all donors ultimately become lung donors. Primary graft dysfunction, which occurs in up to 15% of lung transplant recipients, remains a significant cause of early mortality. Recent studies confirm that the selective use of inhaled nitric oxide (NO) reduces ventilation times, inpatient stays and early mortality in this group. However, inhaled NO does not prevent ischaemia-reperfusion injury, which is the main cause of early graft dysfunction which remains a fertile area for active research. The key preventable morbidities after lung transplant are rejection, infection and drug toxicities. The art of balancing anti-rejection therapies with their attendant morbidities is a subtle one which can be fine-tuned with the use of therapeutic drug monitoring strategies, such as the area under the curve (AUC) monitoring for cyclosporin leading to therapeutic algorithms using single point surrogate measures of AUC, such as the 2 hour post dose (C2) level, which correlates best with the 0-4 hour AUC and hence, tolerability and efficacy. Minimising over-immunosuppression results in lower rates of opportunistic infection. Prophylactic antibiotics, anti-viral therapies and anti-fungal therapies all have a role to play, especially in the recipient who is naïve to cytomegalovirus, Ebstein-Barr virus and Chlamydia pneumoniae. Deep seated fungal infections are the most common late infectious cause of death and may mimic chronic rejection or bronchiolitis obliterans. The treatments are diametrically opposed, so, excluding fungal infection as a cause of loss of graft function is mandatory prior to commencing augmented immunosuppression. Steroidal side effects should not be trivialised and while it may not be possible to withdraw steroids in the majority of patients, active bone management programmes are useful to reduce osteoporotic fractures. Renal dysfunction, which occurs in 38% of patients by 5 years post transplant is multi-factorial, but may be improved by lowering calcineurin inhibitor doses. Finally, the psychosocial impact of terminal illness and the traumas of waiting for and surviving transplant surgery should be taken into account when assessing the overall benefit of this (hopefully) life prolonging procedure.

S4

FUTURE DIRECTIONS FOR LUNG TRANSPLANTATION

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It is now forty years since the first attempt at human lung transplantation and over twenty years since the first long-term survivors were reported. There have been major improvements in early mortality with good units now achieving 85% one-year survival. The availability of lung transplantation remains limited and we still have many problems to solve in the long-term survivors. The key problems we still face are: donor shortages, the frequently severe side effects associated with the immunosuppressing agents (e.g. renal failure) and bronchiolitis obliterans (chronic rejection presenting as progressive airflow obstruction).

The utilization of multi-organ donors for lung transplantation in Australia is very high due to a preparedness to assess and optimise marginal donors. Live-donor lobar transplantation has been performed by some overseas centres for a decade but the likely case volume in Australia is low and thus this procedure is yet to be performed in Australia. Recent reports have shown the feasibility of non heart-beating donation for lung transplantation. This should significantly increase lung transplant numbers and should reach clinical practice in Australia in the next 2 years. Xenotransplantation has been just around the corner for the last 10 years. The likely animal donor is the pig and genetic manipulation does prevent hyperacute rejection. Outstanding issues are the fear of virus transmission to humans (the so-called Porcine Endogenous Retro-Virus or PERV) and the recognition that solving hyperacute rejection is just the start toward any realistic immunological tolerance of the organ. Much further down the track, stem cell therapies may also offer a solution. Although theoretically a whole lung could be generated from a single stem cell, practically it seems likely the approach will be to re-populate the damaged lung to allow repair.

Of more immediate impact is the availability of a newer array of immunosuppressing drugs. Clearly smarter combination with conventional immunosuppressive drugs with agents like rapamycin/RAD, mycophenolate and the IL-2 receptor antagonists should reduce severe side effects and hopefully reduce the incidence of chronic rejection.

O1

ALGORITHMS FOR PREDICTING RESTRICTION USING FVC AND FEV_6

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Introduction: We investigated three algorithms that use spirometry data to predict restriction: American Thoracic Society (ATS)[1], Glady[2] and our own.

Methods: Spirometry data from 219 consecutive patients with spirometry and plethysmographic lung volume measurements were applied to each algorithm. Hankinson's[3] reference equations were used to classify FVC, FEV_6 and their respective FEV_1 ratios. The algorithm's predictions were compared with measured TLC and classified as normal or abnormal using two reference equations (Goldman and Becklake (Goldman) and the Intermountain Thoracic Society (ITS)). Ascertainment bias was analysed by comparing the incidence of restriction in our 'lung volume' population with a 'spirometry only' population.

Results: No ascertainment bias was detected. The TABLE summarizes the positive predictive values (PPV), specificity (Spec) and sensitivity (Sens) values. The negative predictive values were all 99 or 100%.

		Goldman			ITS		
Algorithm	**Variable**	**PPV**	**Spec**	**Sens**	**PPV**	**Spec**	**Sens**
ATS	FVC	54	78	100	39	73	100
	FEV_6	57	82	96	39	76	95
Glady	FVC	37	69	100	28	66	100
	FEV_6	32	63	100	24	60	100
Ours	FVC	49	81	100	38	78	100
	FEV_6	43	76	100	33	73	100

Discussion: Regardless of the reference set or the algorithm, spirometry accurately predicts a normal TLC but poorly predicts restriction (reduced TLC). FEV_6 performs the same as FVC in predicting the presence or absence of restriction.

References:

[1] ATS. *American Review of Respiratory Disease* 1991; 144:1202-1218.
[2] Glady CA, Aaron SD, Lunau M, Clinch J, Dales RE. *Chest* 2003;123:1939-1946.
[3] Hankinson JL, Odencrantz JR, Fedan KB. *American Journal of Respiratory & Critical Care Medicine* 1999; 159: 179-187.

O2

T_LCO IN A MIDDLE-AGED AUSTRALIAN POPULATION

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Introduction: There are many studies describing reference equations for the measurement of the transfer factor of the lung for carbon monoxide (T_LCO). However, like other reference equations for lung function tests, the testing methodologies are quite different, and there are few well-documented studies that develop reference equations for T_LCO using current American Thoracic Society (ATS) guidelines. One of the commonly used reference equations for T_LCO in Victoria is those of Roca *et al* [1] which include a weight term for females. Anecdotally, we have noted that these equations overestimate T_LCO in the female population especially in the higher weight ranges.

Aims: To critically evaluate the reference equations for T_LCO as published by Roca *et al* [1] in a large middle-aged Melbourne population. A secondary aim was to develop our own reference equations using the same population.

Methods: Healthy subjects who have never smoked were recruited as part of a large epidemiological study conducted within the department. All patients had spirometry and single breath T_LCO (corrected for haemoglobin) measurements (Medgraphics Elite DX) following ATS guidelines and a comprehensive respiratory questionnaire. Linear regression was used and the reference equations developed from our data were compared with those of Roca *et al* [1].

Results: 235 male and 326 female subjects were recruited aged between 45 and 70 years (mean 57.4). For the sampled population, the mean T_LCO as a percent predicted using the Roca equations was 90.2±12.6% (mean±SD) for the male population and 84.8±12.5% for the female population. The TABLE compares the prediction equations derived from our data compared with those of Roca *et al* [1].

	Predicted Equation	R^2	SEE
Males			
T_LCO	33.0*Height - 0.134*Age - 22.31	0.32	3.87
T_LCO Roca	36.7*Height - 0.196*Age - 21.90	0.44	4.40
Females			
T_LCO	17.85*Height - 0.212*Age + 0.031*Weight + 1.083	0.38	2.83
T_LCO Roca	13.69*Height - 0.123*Age + 0.092*Weight + 1.888	0.37	2.91

Conclusions: The prediction equations described by Roca *et al* [1] overestimated T_LCO in this population of middle-aged Australians. Prediction equations from our data set show the weight term to be important in females but not in males. However the coefficient for the weight term is smaller than that described by Roca *et al* [1]. The data in this study suggest that the current prediction equations used for T_LCO may not be suitable for a middle-aged Australian population.

O3

IS THERE A LEARNING EFFECT ON SERIAL MEASUREMENTS OF MIPS AND MEPS?

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Introduction: Respiratory muscle strength is commonly assessed by measuring maximum inspiratory pressures (MIPs) and maximum expiratory pressures (MEPs). These manoeuvres are dependent on effort and technique and some people achieve a low value despite no weakness of their respiratory muscles[1]. Trends showing significant improvement of results over a period of time have been observed.
Aim: To investigate the presence of a 'learning effect' when performing maximal pressure tests.
Methods: The results obtained from the first 7 testing sessions in 5 laboratory biological normal subjects were used for analysis. The coefficient of variation (CV) was calculated using the two highest values from each testing session to determine intra-test variation. The highest result from each of the 7 sessions was graphed to show trending and the CV was calculated to determine inter-test variation for each biological normal subject. The percent difference from the first session to the mean of the 7 sessions was calculated.
Results: Intra-test variation decreased in approximately 70% of subjects over time for both MIPs and MEPs measurements, however this decrease in variation was more noticeable for MEPs measurements. Significant improvement was seen over time from the first MIPs and MEPs testing sessions to the mean of the 7 sessions in 80% and 40% of subjects respectively. Inter-test variability was low for FVC and FEV_1 probably due to the strict test criteria.

Subject	Range of Reported Measures (cmH20)		Deviation of 1st test to the mean (%)		Inter-test Variability (CV)			
	MIP	MEP	MIP	MEP	FVC (L)	FEV1 (L)	MIP	MEP
1	84 – 102	103 – 130	-2	9	2.6	2.6	8	11
2	86 – 121	88 – 164	-15	-38	2.4	2.8	9	11
3	131 – 152	166 – 234	9	-10	3.1	4.2	5	16
4	85 – 105	72 – 156	-4	-40	2.8	2.9	10	14
5	58 – 101	85 – 130	-23	-15	1.2	2.2	15.1	13.3

Discussion: Inter-test variability and the significant positive trend over time was more marked during MEP measurements than MIP measurements. This suggests that there is a greater learning effect on serial measurements of maximal expiratory pressures possibly due to greater technical difficulty.
Conclusion: The learning effect on maximal pressure tests could have an effect on the reliability and reproducibility of the results for patients undergoing serial testing. During each testing session subjects should be encouraged to achieve their best effort until results reach a plateau and are reproducible.

References:
[1]Hughes JMB, Pride NB. *Lung Function Tests: Physiological Principles and Clinical Applications*. 2001. Harcourt Publishers, Edinburgh, United Kingdom.

O4

THE FEASIBILITY AND UTILITY FOR THE MEASUREMENT OF RESPIRATORY SYSTEM RESISTANCE IN THE CHILDHOOD ASTHMA PREVENTION STUDY

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Introduction: Measurement of airway function in pre-school children is difficult since spirometry is unreliable in children under age 5. We tested airway function as part of the Childhood Asthma Prevention Study (CAPS) at age 3 years by using the forced oscillation technique (FOT) to measure respiratory system resistance (Rrs). Other groups have performed FOT on children in this age group but only in small numbers.

Aims: To examine the feasibility of using FOT in this population and the relationship of Rrs to history of asthma symptoms at this age.

Methods: Subjects in the present study were 242 children from the CAPS cohort in whom measurement of Rrs was attempted at the 3 year follow-up. Rrs was measured by FOT at 6 Hz (Oscillation pressure ±1.5 cm H_2O) during tidal breathing with cheeks supported, for up to one minute. The measurement was considered technically unsatisfactory if we were unable to obtain at least three successive tidal breaths without leaks or glottal closure. Satisfactory measurements were obtained in 196 (87 males) subjects at baseline (pre-bd). In 142 subjects, further measurements were made after the inhalation of salbutamol 200 μg (post-bd). Subjects with asthma diagnosed by a doctor or at a hospital were classified as asthmatic. Student t-tests were used to compare baseline Rrs in subjects who did and did not complete post-bd measurements and in subjects with and without asthma.

Results: 81% of subjects performed satisfactory baseline FOT measurements with a mean measurement duration of 37±3 seconds. There was no significant difference in baseline Rrs between subjects who did and did not complete post-bd measurements, but in children who did not complete the post-bd measurements the duration of the baseline FOT measurement was shorter ($p \leq 0.001$). Bronchodilator caused a significant decrease in Rrs in all subjects from 13.6(±0.56) to 11.4(±0.43) cm H_2O/L/s (mean(95% Confidence Interval)), a change of 15(±2)%. Asthmatic children had significantly higher Rrs values than non-asthmatic children both pre-bd (15.2(±1.3) vs 13.1(±0.59) cm H_2O/L/s, $p<0.001$) and post-bd (12.3(±0.95) vs 11.1(±0.47) cm H_2O/L/s, $p=0.014$), but the magnitude of the post-bd response was not different (18% vs 15%, $p=0.252$).

Conclusions: We conclude that FOT is a feasible way to measure lung function in most 3 year old children. Subjects who were unable to complete post-bd measurements did not differ physiologically but were probably more restless than those that completed both measurements. FOT at 6 Hz is a sensitive measure of airway calibre since it could detect the decreased calibre in children with asthma and the increase in calibre following bronchodilator in all children. The significance of the improvement in airway calibre following bronchodilator in non-asthmatic children remains unclear.

Support: CRC for Asthma and NH&MRC

O5

"EZY QC": QUALITY CONTROL MADE EASIER

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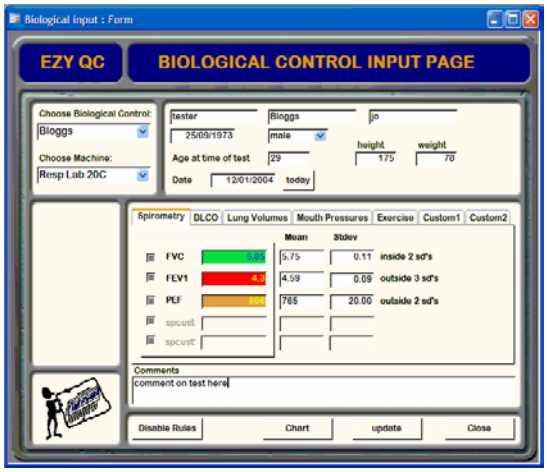
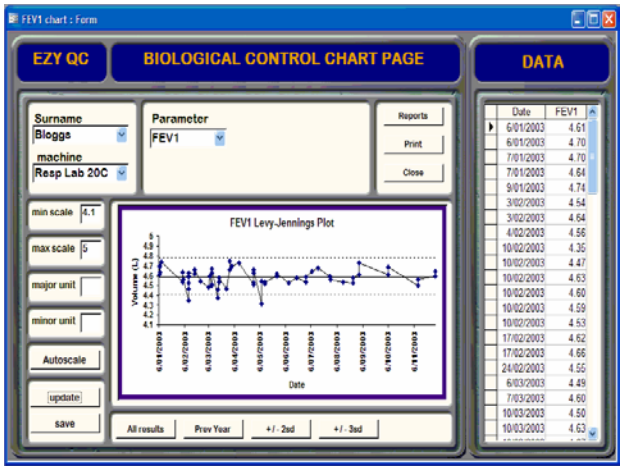
Introduction: Australian and New Zealand Society of Respiratory Science members were asked if a computer program existed for maintaining a respiratory laboratory's quality control (QC) programme and if not, whether such a program would be utilised if developed. Several laboratories replied affirmatively and commented that a user-friendly program would be beneficial.

Aim: To develop a program that is more efficient and user-friendly than Excel spreadsheets currently used to maintain the QC programme of the laboratory.

Design: A Microsoft Access database has been developed by the Palmerston North Respiratory Laboratory based on their current QC programme. This includes both biological control and machine calibration data.
The key components of this program include:

- User-friendly input of data
- Automated updateable graphs (Levy-Jennings plots, comparative graphs)
- Automated warning messages if parameters are "out of control"
- Summaries/Reports
- Comparative results between parameters on different machines
- Access to all biological control and calibration data from the one place (no more hunting through several Excel spreadsheets)
- Mass import of data from existing spreadsheets
- Customisable to different laboratory needs





Conclusions: This program may be beneficial to maintain the quality control programme for respiratory laboratories.

K1

IN DEFENCE OF THE KCO (DL/VA)

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The carbon monoxide diffusing capacity (DL,CO [TL,CO]), with the KCO (DL/VA), measured with the single breath method, is one of the two most useful routine tests of pulmonary function, the other being spirometry. DL,CO is calculated as the product of two components, the *k*CO (~ $\log_e[CO_0/CO_t]$ /BHT) and the single breath alveolar volume (VA), both being measured simultaneously during a breath hold at TLC. CO_0 and CO_t are the alveolar concentrations of carbon monoxide (CO) at the beginning and end of the breath hold time (BHT), respectively. The *k*CO is the slope on a semi-log plot of ΔCO against time, representing the rate of removal of CO from alveolar gas; *k*CO is a rate constant (units of min^{-1} or s^{-1}). Except for a difference in units, *k*CO is equivalent to DL/VA, also called the KCO. As DL,CO = KCO x VA, a low DL,CO must be caused by a low KCO or a low VA, or both, or a combination of a normal or high KCO and a low VA (high VAs are unusual). These patterns have different physiological and pathological connotations.

The KCO (DL/VA) has been criticised for being volume dependent, i.e. it does not "correct" for lung volume variations. The KCO rises as alveolar expansion declines at lung volumes below TLC. The KCO rises also on exercise because the rise in cardiac output increases the capillary blood volume in contact with inhaled CO; at a local level, regional KCO increases if blood flow is diverted from other parts of the lung. These "physiological" variations of KCO, if we take note of them, can be turned to our advantage when we are faced with the question "What does this low value of DL,CO signify?" One useful paradigm is "discrete loss of units" in which a high KCO results from diversion of blood flow and volume from diseased lung to normal units.

There is no simple way to "adjust" the DL,CO for a low VA, because the KCO responds differently according to the cause of the low VA, the KCO being different for a low VA due to a pneumonectomy from that due to acute muscle weakness or to a poor inspiratory effort. For the same value of DL,CO (say 60% Predicted), different combinations of KCO and VA can be chosen which would suggest quite different pathologies, e.g. bronchiectasis or emphysema or pulmonary vasculitis or interstitial pulmonary fibrosis or lung resection or Guillan-Barré syndrome or anti-glomerular basement membrane disease (Goodpasture's syndrome).

References:

Hughes JMB, Pride NB. *European Respiratory Journal* 2001; 17: 168-174.
Hughes JMB. *Clinical Physiology & Functional Imaging* 2003; 23: 63-71.

P1

STERILITY OF METHACHOLINE CHLORIDE OVER 6 MONTHS

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Introduction: Methacholine chloride is routinely used in respiratory laboratories for bronchial provocation testing.

Aim: To compare the sterility of methacholine chloride prepared by our laboratory and prepared by the pharmacy department at Royal Prince Alfred Hospital (RPAH), and stored at -20 ºC and 4 ºC over six months.

Methods: Doubling concentrations of methacholine chloride ranging from 1.55 $mg.mL^{-1}$ to 200 $mg.mL^{-1}$ were prepared in 0.9% NaCl by our laboratory and the pharmacy department at RPAH. Methacholine chloride prepared by our laboratory was prepared using aseptic techniques in a laminar flow hood. Samples were aliquoted into 3 mL syringes and stored at -20 ºC and 4 ºC for 6 months. Every 6 weeks a syringe from each concentration and batch was tested for sterility. Sterility was tested by plating 1 mL of each syringe onto blood agar and incubating the plates for 48 hours at 30 ºC.

Results: No bacterial growth was noted for methacholine chloride ranging in concentration from 1.55 $mg.mL^{-1}$ to 200 $mg.mL^{-1}$, prepared by our laboratory and stored at either -20 ºC or 4 ºC over six months. This was also the case for methacholine chloride prepared by the pharmacy department at RPAH.

Conclusions: Our laboratory can aseptically prepare methacholine chloride in a range of concentrations. The sterility of methacholine chloride is maintained over a six month period for solutions stored at either -20 ºC or 4 ºC.

Support: The Woolcock Institute of Medical Research

P2

STANDARDISATION OF LUNG FUNCTION TESTING: CURRENT PRACTICES IN LABORATORIES IN AUSTRALIA AND NEW ZEALAND

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Introduction: The consistency of outcomes from Pulmonary Function Testing (PFT) depends on standardisation of the equipment used, testing procedures used and interpretation of test results. Equipment in use today should satisfy standards established by the American Thoracic Society (ATS). There is, however, still considerable variability of approach in performing the tests. This variability may relate to patient position (standing or sitting), use of nose clips and approach to assessing bronchodilator responsiveness. Finally, the interpretation of the data critically depends on having appropriate reference equations against which to evaluate results.

Aim: To document whether Australasian Respiratory Function Laboratories (RFLs) are consistent in their practice regarding the listed variables and their impact on testing outcomes.

Methods: ANZSRS members were asked to complete an on-line survey through the Society web-site. A single response was requested from each laboratory. It is estimated that 90% of the membership was given the opportunity to respond. The results were collated, duplicates eliminated (1) and responses tallied for each question.

Results: Responses were received from 50 of an estimated 70 RFLs throughout Australia and New Zealand (an estimated 71% response rate). Both public (34/50) and private (16/50) laboratories were represented in the responses.

Lung function tests were most commonly performed with the patient seated (84%; 42/50). 14% of RFLs (7/50) reported testing with patient either seated or standing, 5 of these RFLs recording whether tests were performed seated or while standing. Only 1 RFL reported using the standing position exclusively.

Nose clips were used for all PFT in 86% (43/50) of RFLs with 14% (7/50) reporting variable use of nose clips. Where use of nose clips was not standardised, 2 of 7 laboratories recorded whether a nose clip was used or not.

The majority of laboratories advised patients to withhold reliever medication (94%; 46/49) or combination preventer/reliever medications (72%; 36/50) prior to the assessment of bronchodilator responsiveness. 35 of 49 RFLs (72%) advised patients to withhold both reliever and combination treatments.

18% of RFLs believed that waiting less than 15 minutes between the administration of bronchodilator and repeating spirometry allowed them to measure maximal response to bronchodilator.

52% (25/48) of RFLs had not validated any of their reference data, 23% (11/48) reported validating their reference data and 25% (12/48) reported partially validating their reference data. Two laboratories did not respond to this question.

Conclusions: The approach to pulmonary function testing by ANZSRS members appeared consistent with the exception that the use of nose clips was not documented when usage was not standardised (5 of 7 RFLs). There appears to be a widespread lack of understanding about bronchodilator responsiveness with variable approaches to withholding combination therapy and time before re-testing. The lack of reference equation validation in the majority of laboratories is of concern with respect to the consistent interpretation of lung function testing results.

P3

EVALUATING THE REPRODUCIBILITY OF THE STEP TEST IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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Introduction: Patients with chronic obstructive pulmonary disease (COPD) frequently have limited exercise capacity. Portable oxygen therapy (POT) may improve exercise capacity by reducing breathlessness and hypoxaemia. A step test is often used to assess objectively, patients who might benefit from POT. The standard protocol comprises a period of climbing up and down a single step (stepping) while breathing supplemental oxygen or placebo (medical air) followed by another period of stepping with the alternative gas, given in a single blinded fashion. Outcome measures include the steps climbed, exercise duration, change in arterial oxygen saturation (SpO2) and heart rate monitored with a pulse oximeter. Subjective assessment is made of breathlessness and leg fatigue using a modified Borg scale applied before and after each stepping assessment.
Aim: To assess the reproducibility of stepping assessments in patients with severe COPD.
Methods: Twenty patients with COPD referred for assessment of the benefit of supplemental oxygen. None of these patients had previously had a step test.
The routine step test was modified to include an additional stepping assessment following the first, breathing the same inspired gas (randomised to oxygen or placebo). Initially the patient was seated and stabilized on the breathing gas mixture for 10 minutes. The procedure was explained and demonstrated to the patient with the emphasis on exercising as long as possible and use of the Borg scale. Baseline measures were recorded and stepping comenced. Stepping was stopped when the patient could not continue, if the SpO2 fell below 75% or after 6 minutes when recordings were repeated and Borg scale applied. Ten minutes rest was given between each stepping assessment.
Results: The mean and SD of the differences between Stepping Assessment 1 and Stepping Assessment 2 are tabulated.

	Steps	Exercise Time (sec)	Change in SpO2%	Breathlessness	Leg fatigue
Mean	-0.45	7.8	0.1	0.1	-2.45
SD	27.9	50.1	1.6	1.4	2.1

The mean differences suggest little difference between assessment 1 and 2. However, the SDs of the steps taken and the exercise time were large which raises concerns about the reproducibility of the test within individuals. Two patients had differences greater than 2 SD.
Discussion: There are several possible explanations for the variability between stepping assessments: A learning effect was expected. However, one patient did better on Stepping Assessment 1 than Stepping Assessment 2 (6 minutes vs 3 minutes) although similar in oximetry and Borg scale ratings. Motivation may have been reduced, or the patient may have failed to recover adequately from the initial test. Worsening leg fatigue may suggest muscle fatiguing effect with repeated exercise.
Conclusions: This study shows unacceptable variability in 10% of patients. We recommend a practice stepping assessment and further research to determine the optimum number and timing of practice tests.

P4

REPEAT EXERCISE MAGNIFIES THE POST-EXERCISE FALL IN CAPILLARY BLOOD VOLUME BUT DOES NOT EFFECT T_LCO BECAUSE OF A COMPENSATORY INCREASE IN MEMBRANE DIFFUSING CAPACITY

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Introduction: It is now well established that the transfer factor of the lungs for carbon monoxide (T_LCO) falls to below pre-exercise levels following heavy exercise and remains low for 6 - 24 hours. We have shown that the exercise-induced fall in T_LCO is due to a fall in pulmonary capillary blood volume (Vc) but this is offset to some extent due to a compensatory increase membrane diffusing capacity (DM). Our results suggest that the cause of the reduced T_LCO is due to redistribution of blood to the previously exercising muscles and not due to the development of interstitial oedema.

Aim: To test the hypothesis that a repeat bout of intense exercise performed when T_LCO was depressed from earlier exercise would magnify the falls in Vc and T_LCO.

Methods: T_LCO and its components, DM and Vc, were measured using a rebreathing method in 9 healthy females (aged 20-30 years) before and at 1, 2, 3, 16 and 24 hours after treadmill exercise to VO_2max (Test 1). A week later the same subjects performed a second maximal exercise test (Test 2) and then a third test 6 hours later (Test 3). T_LCO, DM and Vc were again measured but this time at 1, 2, 3 and 6 hours after Test 2 and at 1, 2, 3, 16 and 24 hours after Test 3. T_LCO was also measured during exercise in Test 2 and Test 3 at work loads corresponding to 60% and 80% of the VO_2max established in Test 1.

Results: Test 1. Compared with pre-exercise values, T_LCO and Vc fell significantly by a maximum of -8.4% (SEM ±1.36) and -19.2% (±4.04), respectively, but DM increased by +16.6% (±9.10) at 3 hours post-exercise. T_LCO, DM and Vc returned to pre-exercise levels after about 16 hours. Compared with resting levels, T_LCO increased 34.2% ± 2.5 at 60% and 46.1% ± 3.35 at 80% of the work-rate. Test 2 and Test 3. There were no significant differences in the percentage increase in T_LCO during the second exercise test compared with Test 1 (T_LCO increased by 32.7% ± 2.57 at 60% and 45.1% ± 3.41 at 80% of the exercise work-rate, respectively). The mean post-exercise drop in T_LCO was greater from rest in Test 3 than Test 2, but the results were not significantly different. However, the post-exercise change in the components of T_LCO were magnified following repeat exercise (Test 3) with the reduction in Vc increasing from -19.2% to -35% but the increase in DM rising from +16.6% to +26.7%.

Conclusions: Our results indicate that the magnitude of any exercise-induced impairment in T_LCO was not significantly increased by repeat intense exercise. However, the post-exercise reduction in Vc was increased following repeat exercise. The net result on T_LCO was offset by a compensatory increase in available membrane surface area. These results do not support the hypothesis that the fall in T_LCO is mainly due to oedema.

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P5

THE ACCURACY OF PULSE OXIMETRY DURING ACUTE HYPOXIA

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Introduction: Pulse oximetry (SpO_2) is a common, simple and immediate clinical procedure used to determine the oxygen saturation of haemoglobin in arterial blood (SaO_2). Frequently, the question arises about the absolute accuracy of pulse oximetry, particularly in association with hypoxaemia. Kelly *et al* [1] reported that SpO_2 had only a fair agreement with SaO_2 in patients with acute exacerbation of chronic obstructive pulmonary disease.
Aim: To determine the accuracy of SpO_2 compared with SaO_2 during induced hypoxia.
Methods: Thirty-one patients with known lung disease (mean FEV_1=63% Predicted; mean D_LCO=51% Predicted) inspired a low oxygen gas mix (LOGM), F_IO_2=0.15) via a one-way breathing circuit for 20 min while sitting, followed by a 50m walk on a treadmill while breathing the LOGM. Arterial blood was sampled before the test (F_IO_2=0.21), after 20 min of breathing the LOGM, and at the conclusion of the 50m walk. SaO_2 was measured using multi-wavelength co-oximetry. Pulse oximetry (Quartz Q-400) was measured continuously during the study using a finger sensor. The test was terminated if SpO_2<80%. Pearson correlation and bias plots (Bland-Altman) were used for the statistical analysis.
Results: A total of 82 sample-pairs (SaO_2, SpO_2) were collected from the 31 patients exposed to the three conditions. Four patients were excluded because SpO_2<80% and seven arterial samples could not be collected at the end of the exercise test. The test induced significant hypoxia (PaO_2<50 mmHg) in 68% of the patients during the 20 min of LOGM breathing and 85% of the patients during the 50m walk. The correlation coefficient between SaO_2 and SpO_2 for the three conditions (combined) was r=0.95. There was no significant difference between SaO_2 and SpO_2. The bias plot of all the data indicated a constant bias of 1.1% with the 95% limits of agreement between -3.5 to 5.8%.

	n	PaO_2 mmHg	SaO_2 %	SpO_2 %	95% limits of agreement*
F_IO_2 0.21 rest (mean ± SD)	31	81.7 ± 7.6	96.0 ± 1.2	96 ± 2	-2.3 to 2.9
F_IO_2 0.15 rest (mean ± SD)	31	49.1 ± 7.1	85.7 ± 5.0	87 ± 5	-3.6 to 6.5
F_IO_2 0.15 walk (mean ± SD)	20	41.6 ± 5.6	79.2 ± 5.3	81 ± 4	-4.0 to 7.9

*Bland-Altman plot

Conclusions: There was a good correlation between SaO_2 and SpO_2, which is consistent with the literature. The bias of the sample pairs was constant and proportional at 1.1%. The 95% limits of agreement increased for each condition, indicating a widening of the discrepancy between SaO_2 and SpO_2 with increasing hypoxia. Of the total 82 sample-pairs, 7 data points fell outside the 95% confidence limits. Despite the good correlation between SaO_2 and SpO_2, this study indicates significant inaccuracy in pulse oximetry compared to arterial oxygen saturation; the error increases during hypoxia.

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P6

RELIABILITY OF THE MICROMEDICAL MICRO-GP SPIROMETER: IS THERE AN ALTERNATIVE TO DAILY CALIBRATION/VALIDATION?

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Introduction: American Thoracic Society (ATS) recommendations for spirometry require a daily calibration or accuracy check with a 3-litre syringe[1]. However, the cost of a 3-L syringe has lead to a suggestion this daily requirement be relaxed in the general practice setting. Accuracy checks using a 3-L syringe performed at "regular intervals", plus regular biological control testing is a suggested alternative[2]. **Aims:** To evaluate the short-term reliability of the Micromedical MicroGP spirometer and determine an appropriate interval between 3-L syringe accuracy/calibration checks. **Methods:** Three MicroGP spirometers were used. Baseline measurements of a 3-L syringe plus biological control spirometry were recorded. Each system was then used to record spirometry on a daily basis for 7 weeks. Daily checks with a 3-L syringe, and weekly biological control testing were performed. The systems replicated different clinical settings that may be encountered in general practice. 'System A' was a low use system (1 subject/day). The flow head was not cleaned. 'System B' was a high use system (6 subjects/day). Again, the flow head was not cleaned during the study. 'System C' was also a high use system (6 subjects/day), however, the flow head was cleaned weekly, according to the manufacturers specifications. Coefficients of Variation (CV) of the weekly biological control measurements were calculated. Differences in the daily 3-L syringe readings were assessed using ANOVA for repeated measures. **Results:** System A: There was no significant change in 3-L syringe readings from baseline on any day. The CV for FEV_1 & FVC was 1.5 & 1.9%. System B: No significant change in 3-L syringe readings from baseline on any day. CV for FEV_1 & FVC was 1.7 & 1.5%. System C: There was a small statistically significant change ($p < 0.05$) in 3-L syringe readings from a baseline of 3.1 ± 0.06 on 5 days. The lowest value was 3.03 ± 0.021 ($p=0.007$). Three of these significant values occurred in Week 7. There was no change in biological control spirometry. CV for both FEV_1 & FVC was 1.4%. **Conclusions:** The short-term reliability of all 3 spirometers was quite good with no change in biological control measurements on any of the systems. There was no difference in daily 3-L syringe measurements of Systems A & B over the study period. There were significant changes in the 3-L syringe measurements of System C. Interestingly, this was the only system that was cleaned during the study period, raising the possibility the cleaning process may have some effect. Retrospective analysis suggests the reliability of all 3 systems was sufficient to render daily 3-L syringe checks unnecessary, and perhaps an interval of every 4-6 weeks could be realistically considered, provided regular biological control studies were also performed and carefully monitored. Such a protocol cannot be considered equivalent to the ATS recommendations required of a diagnostic instrument located in a Respiratory Laboratory. However, it may be a realistic goal for a general practice performing regular spirometry. It is important to note the suggested "regular interval" of 4-6 weeks applies only to the MicroGP spirometer and an appropriate "interval" needs to be individually determined for all other models of spirometer. Continuation of this study will assess both the long-term reliability and the suitability of the proposed QA model for the MicroGP spirometer.

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P7

REPEATABILITY AND INTER-OPERATOR AGREEMENT OF ACOUSTIC RHINOMETRY IN CHILDREN

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Introduction: Previously there has been no reliable quantitative method of assessing interior nasal dimensions in children. Acoustic rhinometry is a suitable method for all ages including infants and young children.
Aims: The aim of this preliminary study was to assess the repeatability of acoustic rhinometry in a group of children aged six to twelve years when tested at an interval of one hour. Inter-observer reproducibility was also assessed.
Methods: Acoustic rhinometry uses reflections of sound waves to estimate (using a mathematical algorithm) the dimensions of the nasal cavity. We performed acoustic rhinometry (Rhinometrics: SRE2000, Lynge, Denmark) on a group of 12 children ranging in age from six to twelve years (8 girls; height: 135 (116-151) cm (mean (range))). The children were tested by two operators and measurements repeated with an interval of one hour between tests.
Children were seated and breathing quietly. During the test, the probe was positioned so as to form a seal with either the left or right nostril. When the adaptor had been successfully fitted, the child was asked to hold their breath momentarily whilst the area-distance function of the nasal cavity was recorded. Both nostrils were tested with the acoustic probe removed between each measurement. Measurements were stored for later examination.
The minimal cross-sectional area (MCA) and volume (Vol) for the left and right (L or RMCA and L or RVol) nostrils were obtained and the mean and standard deviation of each set was calculated. A measurement set was considered technically acceptable if a minimum of three measurements could be analysed.
Bland-Altman analysis was used to compare measurements and determine the repeatability of the acoustic rhinometry technique. Inter-class correlations (kappa statistics) were used to assess inter-observer agreement.
Results: Technically acceptable data were obtained in nine children. Mean differences for RMCA and LMCA were -0.021 and 0.013 cm^2, respectively. RVol and LVol mean differences were -0.087 and 0.044 cm^3, respectively. The coefficients of repeatability were 12.4% (RMCA), 16.6% (LMCA), 13.6% (RVol) and 26% (LVol).
Inter-observer reliability was excellent for both LMCA and LVol (Inter-class correlation coefficients: 0.91, $p<0.000$ and 0.87, $p<0.001$, respectively) but poor for both RMCA and RVol (0.054, $p=0.45$ and 0.48, $p=0.09$).
Discussion: The minimum cross-sectional areas and volumes obtained using the acoustic rhinometry technique are moderately repeatable over a short period of time in school-aged children. Inter-observer reliability was excellent for data calculated from the left nostril but not the right. These observations would suggest that operator training may play a significant role in both the repeatability and inter-observer reliability of the acoustic rhinometry technique in children.
Conclusions: Acoustic rhinometry is minimally invasive, can be easily applied to school-aged children and appears to be a suitable method for evaluating the anterior nasal cavity. Further studies need to address the technician training period required and to assess the repeatability of the technique in infants and pre-school aged children.

P8

THE IDEAL SOLUBILITY FOR MEASUREMENT OF PULMONARY BLOOD FLOW FROM GAS EXCHANGE

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Introduction: Measurement of pulmonary blood flow (Q) from inert gas uptake by the lung using indirect Fick breath-holding, rebreathing, or open circuit wash-in techniques, is affected by the precision (reproducibility) of measurement of gas uptake by the lung. A gas 'G' whose solubility in blood and lung tissue is such that a change in its measured expired alveolar partial pressure at time t (PA_{Gt}) most sensitively reflects a change in Q (maximal dPA_{Gt}/dQ) will give greatest precision of measurement of Q.
Aim: To determine the precision of Q measurements in the presence of V/Q inhomogeneity.
Methods: A multi-alveolar compartment computer model was made of respiratory gas exchange with a given inspired concentration of inert gas G (FI_G = 1.0%) and blood/gas (λ_{GB}) and tissue/gas (λ_{GL}) partition coefficients. Each compartment contains gas and lung tissue phases in series with a common deadspace compartment. Physiological distributions of expired alveolar ventilation (V_{AE}) and Q were nominated whose inhomogeneity is given by their log standard deviation (log SD). Compatible distributions of lung capacitance (Vc) were derived from Brudin *et al* [1]. In each compartment, PA_{G_t} and dPA_{Gt}/dQ were calculated from mass balance principles, assuming initial PA_{G_t} =0. Flow weighted averaging gives dPA_{Gt}/dQ for the whole lung.
Results: Figure 1 plots dPA_{Gt}/dQ vs λ_{GB} and Figure 2 dPA_{Gt}/dQ vs V_{AE}/Q for the rebreathing manoeuvre. dPA_{Gt}/dQ is maximal where λ_{GB}=Vc/Q(1-FI_G)*t. Thus higher λ_{GB} is better early during wash-in prior to recirculation, and at low cardiac outputs (Figure 1). The precision of gases improves the performance of less soluble gases with increasing inhomogeneity of V_{AE}/Q.
Conclusions: The ideal gas depends on the range of Q to be measured and clinical situation. Most gases used historically lie near the ideal point.

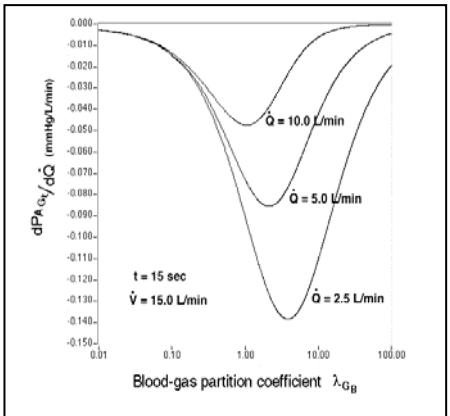

Figure 1

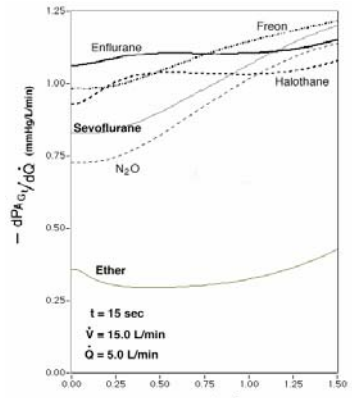

Figure 2

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O6

RISK FACTORS FOR NEAR-FATAL ASTHMA IN CHILDREN

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Aim: To identify risk factors associated with near-fatal asthma in paediatric patients.

Design and Setting: A retrospective case-control study was done at Monash Medical Centre (MMC), a tertiary referral hospital in Melbourne.

Subjects: Asthmatics admitted to intensive care (n=52) were defined as cases of near-fatal asthma (NFA). They were compared to asthmatics who had been admitted on one occasion only to the emergency department at MMC (controls, n=53).

Methods: Patient files were examined and factors possibly linked to NFA were recorded. Information not on file was obtained from patients/parents during a structured telephone interview. Data for the two groups were compared and odds ratios (OR) were calculated. Univariate and multivariate analyses were done.

Results: Asthmatics with NFA were more likely to be male (p=0.05), older (p=0.01), have younger siblings (p=0.05) and have a longer duration of asthma (p=0.02). They were also more likely to have hay fever (OR 7.6; p=0.002), use inhaled corticosteroids (p=0.001), long-acting β_2 agonists (p=0.02), have an asthma management plan (p=0.006), see a respiratory specialist (p=0.001) and have poor adherence with medication (p=0.003). Parental smoking showed no differences between the groups. Multivariate analysis identified male sex (OR 5.7; p=0.05) and inhaled corticosteroids (p=0.07) as factors associated with NFA.

Conclusions: Our study identifies a number of factors associated with NFA; many are similar to those found in adult patients. Asthma severity may explain some of our findings but our data also suggest that other independent risk factors may operate in children.

O7

VENTILATORY CHANGES BETWEEN HEAD-UP TILT AND STANDING ARE DUE TO DIFFERENCES IN ENERGY EXPENDITURE

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Introduction: Passive head-up tilt (HUT) is commonly used to aid rehabilitation in intensive care patients. HUT increases ventilation in healthy subjects, however, controversy surrounds the proposed mechanism.

Aim: To evaluate the possible mechanism for changes to ventilation following passive HUT and standing by comparing a range of ventilatory, metabolic and mechanical parameters.

Methods: Ventilatory parameters, functional residual capacity (FRC), respiratory mechanics with impulse oscillometry; oxygen consumption (VO_2) and carbon dioxide production (VCO_2) were measured in 20 healthy male subjects whilst supine, following HUT to 70º and unsupported standing. Data were analyzed using a linear mixed model.

Results: HUT to 70º from supine increased minute ventilation (V_E) ($p<0.001$) and tidal volume (V_T) ($p=0.001$) with no change in respiratory rate (f) ($p=0.488$). Increased V_E was associated with increases in FRC ($p<0.001$), respiratory system reactance (X5Hz) ($p<0.001$) with a fall in respiratory system resistance (R5Hz) ($p=0.004$) compared to supine. Standing increased V_E ($p<0.001$) and V_T ($p<0.001$) with no change in respiratory rate (f) ($p=0.065$) with similar changes in FRC ($p<0.001$), R5Hz ($p=0.013$), X5Hz ($p<0.001$). In contrast to HUT, standing increased VO_2 ($p=0.007$) and VCO_2 ($p=0.009$). HUT increases ventilation in healthy subjects by increasing V_T and is associated with increases in FRC and X5Hz and a fall in R5Hz.

Conclusions: The greater increase in V_E in standing compared to HUT appears to be related to increased VO_2 and VCO_2 associated with increased muscle activity in the unsupported standing position. This may have implications for exercise prescription and rehabilitation of patients in intensive care.

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O8

THE BUTEYKO METHOD INCREASES END-TIDAL CO_2 AND DECREASES VENTILATORY RESPONSIVENESS IN ASTHMA

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Introduction: The Buteyko breathing technique has been shown to improve the quality of life and to reduce medication requirements in asthma. Proponents of the Buteyko method believe that asthma is caused by low CO_2 levels due to hyperventilation and teaches breathing techniques to raise CO_2 levels in the body.
Aims: 1. To identify the most effective way of delivering the Buteyko method & 2. To investigate the hypothesis that Buteyko training may reset central chemoreceptor sensitivity to CO_2.
Methods: A double blind randomised controlled trial was conducted with 4 parallel groups: G1. Buteyko practitioner + Placebo video, G2. Asthma educator + Buteyko video, G3. Asthma educator + Placebo video, and G4. Buteyko practitioner + Buteyko video. Ninety-five subjects with doctor diagnosed asthma were recruited, aged 18-65 years, of whom 72 completed the 10 week trial. Subjects kept daily asthma symptom and medication diaries, completed validated quality of life questionnaires (QLQ)[1,2] and had spirometry measurements on 3 visits to the laboratory . End-tidal CO2 ($etCO_2$), mixed-expired CO_2 (mCO_2) and minute ventilation (MV) were measured over a two-minute period with the subjects breathing through a low dead space valve attached to a mixing chamber and rolling seal spirometer. Dead space to tidal volume ratio (V_D/V_T) was calculated by ($etCO_2$-mCO_2)/$etCO_2$. Ventilatory response to CO_2 ($VRCO_2$) was measured using a rebreathing method[3] from a plot of Ventilation vs CO_2. The plots were analysed for slope ($VRCO_2$) and y-intercept. Data were analysed by intention to treat utilising linear regression models fitted by generalised estimating equations.
Results: Mean (SD) baseline FEV_1 was 75.3 (19.9) %Predicted and FEV_1/FVC ratio was 68 (10)%. No significant differences among the four groups were found in spirometry, V_D/V_T, $VRCO_2$ y-intercept or QLQ scores. Changes in mean $etCO_2$ across visits differed among groups with a significantly greater increase in G4 compared with G3 (4.8 mmHg, p=0.002). There were differences among groups in the mean change in $VRCO_2$ across visits with G2 having a greater decrease in mean $VRCO_2$ than G3 (-0.7 L/min/mmHg, p=0.005).
Conclusions: The combination of a Buteyko practitioner and Buteyko video was associated with an increase in $etCO_2$. The Buteyko video alone demonstrated a fall in $VRCO_2$ suggesting a reduction in central chemoreceptor sensitivity. There was no significant change in spirometry following intervention between groups and we were unable to confirm previous findings of an increase in quality of life among asthma patients using the Buteyko method.

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O9

PERTH QUALITY ASSURANCE PROJECT. HOW WELL ARE WE DOING?

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Introduction: The Perth Quality Assurance (QA) Project was initiated to provide benchmarks for Pulmonary Function Testing across Perth. The laboratories involved to date are Royal Perth, Sir Charles Gairdner and Princess Margaret Hospitals and Lung Function Services, Mount Medical Centre.
Aim: To formally assess the variability of measurement between the laboratories in Perth. A second, and equally important aim, is to develop a feedback system for the laboratories participating in the project, regarding the accuracy of their measurements.
Methods: 6 trained subjects visited each of the 4 participating laboratories over the course of 4 weeks and completed a full set of pulmonary function tests. Testing equipment used included Hewlett Packard, MedGraphics, Morgan and SensorMedics. The consensus mean (mean of measurements across all laboratories) and coefficient of variation (CV) were determined for each individual and each parameter studied across all laboratories. A bias was calculated for each laboratory from the mean of differences between measured and consensus value for all subjects tested at that laboratory. The bias and CV formed the basis of the report that was subsequently provided to each laboratory.
Results: The average CV, as a percentage, across all study laboratories were compared with those reported by Brown *et al*[1] and by Swanney *et al*[2]:

	FEV_1	FVC	FEF_{25-75}	D_LCO	VA	TLC	FRC
PERTH AVERAGE	4.6	3.7	7.7	6.2	3.3	2.5	8.9
BROWN	5.2	4.3	-	5.4	-	2.0	6.7
SWANNEY	4.1	3.7	12.4	7.7	8.0	5.1	12.8

The CV for the spirometric parameters is remarkably similar between studies. D_LCO variability is also similar but there was a marked difference between male and female subjects with males generating a CV of 2.0±0.5% and females 10.3±1.6%. The difference between mean values between genders accounts for only 40% of this discrepancy. Interestingly the same discrepancy between sexes was not seen with VA. Concordance was good with TLC whether measured by gas dilution, N_2 washout or plethysmography, with a CV of 2.5%. Comparison of the lab biases showed a similar trend, with the TLC measurement having the smallest biases (+1.8 to –1.9%). The largest biases were for FEF_{25-75} (+7.1 to –10.5%) and for D_LCO (+5.7 to –3.9%).
Conclusions: Our internal QA informs about precision. Bias by external QA informs about accuracy. In the absence of knowledge of the "right" value, accuracy can only be determined by making measurements on multiple systems, with multiple operators and using a consensus value. Consistency of results appears to be better than was observed by Swanney[2] in 2001 and comparable to that reported by Brown[1] in 2003. Large biases in FEF_{25-75} may indicate sensitivity to technique or computation method. The feedback report based on bias gives a clear indication of where each measurement in each lab relates to the others. Trends with time can also be clearly seen. The data presented here indicate that Perth laboratories are generally accurate and are no worse than reported in other studies. This survey will be repeated quarterly and once accuracy is established between labs we will commence multi-centre studies.

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